DEC 19 1916
UNIV. OF MICHIGAN
LIBRARY

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2656.] *LONDON: FRIDAY, NOVEMBER 24, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT.
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS
CEMENT-MAKING MACHINERY. 5268

A. G. Mumford Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 29.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. Oct 2179

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 4986

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4457
See Advertisement last week, page 91.

Plenty and Son,
LIMITED.
MARINE ENGINES, &c.
NEWBURY, ENGLAND. 0083

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 4988

Rubber MANUFACTURERS
Packings "Redstone" "Bluestone"
GUTTA PERCHA & RUBBER, LIMITED,
Toronto Canada. 3211

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 6055

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Oct 3547
Registered Offices: 105A, Cannon St., London, E.C.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS. Oct 1894
11, BILLITER SQUARE, LONDON, E.C.

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Oct 9713

Iron and Steel
Tubes and Fittings.
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow,
BRANCH OFFICES:
London, Liverpool, Manchester, Newcastle-on-Tyne, and Cardiff. 5326

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON).
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught.
VESSELS PROPELLED BY STEAM
Turbines or
Internal Combustion Engines. Oct 8759

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Oct 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

FOR
Drop Stampings
write
GARTSHERRIE ENGINEERING & FORGE CO., 80, WELLINGTON STREET, GLASGOW. 5433

OIL FUEL APPLIANCES.
Systems
PRESSURE, AIR, STEAM.
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool; and
109, Fenchurch St., London.
Naval Outfits a Speciality.
4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Oct 2487
See their Illustrated Advertisement page 99, last week

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 92, last week. 5020

Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 30.
BRITISH STEAM SPECIALITIES, LTD.,
Bedford Street, Leicester. 3920

"Gripoly."
MACHINE BELTING
FOR
Driving
—
Conveying
—
Elevating
SOLE MANUFACTURERS:
Lewis & Tylor, Ltd.,
CARDIFF. 5434
LONDON. MANCHESTER. GLASGOW.

Experimental and Research
WORK UNDERTAKEN
BY
THE AERONAUTICAL INSTITUTE OF GREAT BRITAIN
at their Experimental Workshop and Industrial Laboratory. 5343
Offices: 3, Arlington Street, St. James's, S.W. Tel.: Gerrard, 5466.
Workshop & Laboratory: 45, Horseferry Road, Westminster. Wire: Zepstraffs, London.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1316
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes, Iron and Steel.
Edwin Lewis & Sons, 4912
London Office: 143, Cannon St., E.C. Wolverhampton.

Tubes and Fittings.
—
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 101. 4900

Shell Lathes
FOR
Immediate Delivery.
—
A large number of heavy up-to-date American-made SHELL BORING LATHES; most of them new and unused, some few very slightly used (found to have been purchased in excess of needs) are FOR SALE in the United States.
—
For further particulars, address—
THE BALDWIN LOCOMOTIVE WORKS,
34, VICTORIA STREET,
LONDON, S.W.

The Norman Thompson Flight Co., Ltd. (ESTD. 1909.)
CONTRACTORS TO THE ADMIRALTY.
Seven years' experience
in Design and Construction of Aircraft.
—
"THE FIRM WHO GAVE THE FLYING BOAT TO THE NAVY."
ALL BRITISH BUILT.
5399
Address:—MIDDLETON, BOGNOR, ENGLAND.
Telegraph—"Soaring, Bognor." Telephone—46 Bognor

Cement.—Maxted & Knott,
LTD., Consulting Engineers to the British Portland Cement Manufacturers, Ltd., ADVISE GENERALLY on proposed Cement Schemes FOR ABROAD, ADVICE ONLY. Highest references. Established 1890. Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull. 5394

Mechanics and Metals
National Bank
OF THE CITY OF NEW YORK
ESTABLISHED 1810.
CAPITAL (Fully Paid) - $6,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with a prudent and conservative banking methods.
CORRESPONDENCE INVITED.
FOREIGN DEPARTMENT.
Finances Exports and Imports, Buys and Sells Foreign Exchange, Telegraphic Transfers, &c., and makes Collections on all parts of the world.
LONDON BANKERS. 5462
LONDON JOINT STOCK BANK, LTD.
LONDON, CITY & MIDLAND BANK, LTD.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } Row's
CONDENSERS, AIR HEATERS, } PATENTS
STEAM AND GAS KETTLES.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 4994

Yarrow Patent Water-tube Boilers. 4995
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Oct 3893

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 5304
See Full Page Advt. page 48, Nov. 17.

Punch and Shear Machine
SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

Forgings.
Walter Somers & Co., Ltd.,
HALIFAX.

Taylor & Challen Presses.
8165

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 5449

Delta Metal. HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 4906
Offices & Works: EAST GREENWICH, LONDON, S.E.

Cranes (Birmingham) Limited
103, MOSELEY STREET, BIRMINGHAM,
for
Die Castings
in White and Yellow Metal.
Drop Stampings
in Yellow Metal and Steel.

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 5324
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
See half-page Advertisement, last and next week.

CHANTIERS & ATELIERS
Augustin-Normand
61, rue de Penfer—LE HAVRE (France.) 3993
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
—
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 5468
See half-page Advertisement page 76, Nov. 3.

The Manchester Steam Users' ASSOCIATION.
For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir W. Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5169

A National Need.
BRITISH SCHOOL OF AERONAUTICS.
Aeroplanes and Airships. Construction, Design and Draughtsmanship. Complete Postal Courses. Also preparation for Exams. of Institutions of Civil, Mechanical and Electrical Engineers.—PENNINGTONS, 254, Oxford Road, Manchester. 5307

TENDERS.

AUCKLAND HARBOUR BOARD.
TENDERS FOR MILD STEEL OR IRON GATES AND FENCES.

Tenders will be received until January 31st, 1917, for the SUPPLY of MILD STEEL or IRON GATES and FENCING for Quay Street Frontage, Auckland.
Specifications and Forms of Tender may be obtained on application to the undersigned, and Drawings may be inspected at their address.
Tenders must be endorsed on envelope *Tender for Gates and Fencing*, and must be accompanied by a deposit of £50 under separate cover, both addressed to W. & A. McARTHUR, Ltd., the London Agents of the Auckland Harbour Board. Tenders will be forwarded to Auckland, but the deposits will be retained in London and returned to unsuccessful tenderers on receipt of a cable from Auckland. The lowest or any Tender not necessarily accepted.
By Order of the Board,
W. & A. McARTHUR, Ltd.,
Canberra House, 18/19, Silk Street,
Crippiegate, London, E.C. F 535

CORPORATION OF CALCUTTA.
NOTICE TO CONTRACTORS.

Tenders are Invited, in duplicate, for STORM WATER PUMPING PLANT, and will be received by the Deputy Chairman of the Corporation up to Two p.m., on Friday, the 1st June, 1917, when they will be opened in the presence of such tenderers as may be present. Each Tender, in duplicate, must be enclosed in a sealed cover and superscribed, "Tender for Storm Water Pumping Plant." Further particulars may be had by applying to the Chief Engineer, Municipal Office, Calcutta. Specifications, with site drawings, contract agreement, Tender form and rules with regard to Tenders, may be obtained from the office of the *Indian and Eastern Engineer*, 50, Fenchurch Street, London, England (or at Calcutta, from the Secretary to the Corporation), on payment of Ten Shillings for each combined copy. Tenderers must abide by the Corporation rules in regard to Tenders. Tenders must hold good for at least two months from the date of opening of the same.
C. C. CHATTERJEE,
Secretary to the Corporation.
Central Municipal Office,
22nd October, 1916. F 554

CITY OF SHEFFIELD: ELECTRIC SUPPLY DEPARTMENT.
SALE OF PLANT.
The Electric Supply Committee of the City of Sheffield are prepared to receive

Tenders for the Under- mentioned GENERATING PLANTS.
One Cross Compound Steam Engine, by Browett-Lindley & Co., direct coupled to Ferranti Alternator, 200 Kw. single phase, 100 periods, 2000 volts.
One Marine Type Steam Engine, by McLaren, direct coupled to Ferranti Alternator, 125 Kw., single phase, 100 periods, 2000 volts.
One Vertical Two-Crank Tandem Universal Steam Engine (disabled), by the Brush Electrical Co., direct coupled to a Mordey Alternator, 300 Kw., single phase, 100 periods, 2000 volts.
One Browett-Lindley & Co. Jet Condenser, complete with Steam Engine, capacity 15,000 lb. per hour.
One Induction Motor, single phase, 15 Kw., complete with Starter.
The above plants can be seen by appointments.
Tenders to be endorsed, "Tender for Plant," addressed to the undersigned, and delivered on or before 5th December, 1916.
GENERAL MANAGER AND ENGINEER.
Commercial Street, Sheffield.
17th November, 1916. F 559

APPOINTMENTS OPEN.

British Municipal Council, TIENTSIN, NORTH CHINA.—The Council is prepared to receive APPLICATIONS from British subjects for the POST of MUNICIPAL ENGINEER. Candidates will be required to pass a medical examination as to their physical fitness for the position.—Applications should state age, qualifications, salary required, &c., and should be forwarded, together with copies (not originals) of testimonials and particulars of previous employment and experience, on or before December 31st, 1916, to F 449, Offices of ENGINEERING.

The Aeronautical Society of GREAT BRITAIN invites Applications for the full-time APPOINTMENT of a SECRETARY. Salary, £300 per annum.
Applications, giving details of qualifications, which need not include technical aeronautical knowledge, should be addressed to the CHAIRMAN OF THE COUNCIL, at the Offices of the Society, 11, Adam Street, Adelphi, W.C. F 524

NORTHAMPTON POLYTECHNIC INSTITUTE, LONDON, E.C.

Applications are Invited for the Full-time Appointment of DEMONSTRATOR in the Department of Electrical Engineering and Applied Physics. Salary £125 per annum. Applicants must be ineligible for Military Service.—Particulars and Forms of Application can be obtained on application to R. MULLINEAUX WALMSLEY, D.Sc., Principal. F 540

Wanted, in a London ENGINEERING COLLEGE, a TEACHER of Practical Mathematics and Machine Construction and Drawing, &c. Only men over military age, or discharged soldiers with engineering and teaching experience eligible. Salary £180 to £200. Copies of testimonials and full particulars of experience by letter only.—Address C. E., 5, St. George's Terrace, Regent's Park Road, N.W. F 564

General Manager Wanted for important Rolling Stock and Engineering Works, in England; energetic and thoroughly capable man; must be good organiser who would be responsible to Board only; excellent prospects for suitableman.—Address, in confidence, giving full particulars of experience and salary required, to F 512, Offices of ENGINEERING.

Malleable Iron Foundry (Con- trolled) employing 80/100 hands, open for first-class WORKS MANAGER. No person already engaged on Government work need apply. —Applications, in writing, to nearest LABOUR EXCHANGE, quoting No. A 2537. F 516

Works Manager for Munition Works, London district, engaged on mass production of small engineering parts. Highest references and previous similar experience in important works necessary. No man already engaged on Government work need apply.—Write, in the first instance, to nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, quoting No. A 2580. F 518

First-class and Fully Qualified Stores ACCOUNTANT WANTED, at once, for large factory. Must be experienced in all duties appertaining to store-keeping and stores accountancy; also accustomed to prime costing. Preference given to applicant holding C.A. or other similar certificate. State full particulars and salary required.—Address, F 511, Offices of ENGINEERING.

Chief Accountant Required, for large Midland engineering works, employing 3500 workpeople. He will be required to exercise effective control over accounts, costs, purchases, and wages. Responsible technical assistance exists in each department. Purpose of new appointment is to secure responsible financial control. Replies will be treated in strict confidence, and must state age, precise details of experience, and salary expected.—Address, F 501, Offices of ENGINEERING.

A Well-known Merchant and Financial House in London REQUIRES a first-class ENGINEER with commercial experience to travel in Russia in the interests of British manufacturers. Liberal salary and expenses will be paid to an experienced, enterprising man.—Apply, by letter in first instance, giving full particulars and references, to "Z.Y.634," care of DEACON'S, Leadenhall Street, London, E.C. F 539

An Engineer, Experienced in the management of large waterworks, and ineligible for Military Service, REQUIRED during the period of the War to act as assistant.—Apply, to R. ASKWITH, M. Inst. C.E., South Road, Bishop Auckland. F 551

Wanted Engineers to make Machines from Broom & Wade, Ltd., Drawings and Patterns.—Address, F 513, Offices of ENGINEERING.

Wanted, by Midland Engi- neering Firm, working under Government control, ASSISTANT in Sales Department. Must be good correspondent, conversant with general engineering manufactures, and capable of handling shipping consignments, general deliveries, shop progress, reports, &c. No one employed on Government work will be engaged.—Apply, to nearest BOARD OF TRADE LABOUR EXCHANGE, stating in detail previous experience and salary required. Mention this paper and reference No. F 487.

Wanted, by a London Elec- tric Supply Co., an ASSISTANT ENGINEER, to take charge of a watch at one of their stations. Must be ineligible for the army.—Address, stating age, experience, and enclosing copy of recent testimonials, F 468, Offices of ENGINEERING.

Wanted, Assistant Civil ENGINEER, for War work; thoroughly competent in setting out.—Write stating age, experience, salary required, &c., to F 532, Offices of ENGINEERING.

Jig and Tool Draughtsmen REQUIRED immediately, for motor car work. No person on Government work or eligible for the army will be engaged.—Apply, your nearest LABOUR EXCHANGE, quoting No. A 2485. F 500

Draughtsman Wanted.—Plant, jig and tool work in Government controlled establishment. Previous experience essential. State age and salary required. No person already employed on Government work will be engaged. — Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 495.

Wanted, Several Good DRAUGHTSMEN, with mechanical engineering experience. No person resident more than 10 miles away, or already employed on Government work will be engaged.—Reply by letter, giving full particulars, age, experience, and salary required, to The SOPWITH AVIATION CO., Ltd., Kingston-on-Thames. F 358

Wanted, a Good Draughts- MAN, thoroughly conversant with internal combustion engines, both petrol and oil.—Apply, stating experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 541. No one employed on Government work will be engaged.

Good Engineering Draughts- MAN WANTED by controlled firm, Liverpool. Knowledge ship repairing an advantage. No one already engaged on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 547.

Chief Draughtsman, also DRAUGHTSMAN WANTED, for Munition Factory; one with good all-round mechanical experience. Able to get out new designs, and improve existing tools, &c. No one already on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2582. F 542

Wanted, Three Draughtsmen thoroughly conversant with either Blast Furnace or Steel Works practice, for large Government controlled Iron and Steel Works on the North West Coast. Permanency to suitable men.—Applications should be forwarded to the nearest LABOUR EXCHANGE, quoting No. A 2322. Draughtsmen already engaged on Government work cannot be engaged. F 294

Draughtsmen.—Wanted, for Government work, several first-class DESIGNERS and others.—Apply, your nearest EMPLOYMENT EXCHANGE, with testimonials and full particulars of experience, mentioning this Journal and F 544. No one already on Government work will be engaged.

General Engineering DRAUGHTSMAN WANTED. State age, salary and experience. No one already engaged on Government work, or outside a radius of 10 miles from London, need apply.—Address, F 466, Offices of ENGINEERING.

Competent Draughtsman WANTED in London district, with good mechanical engineering, preferably machine-tool experience. No man already on Government work can be engaged.—Apply, stating qualifications, age, salary and earliest date when at liberty, to nearest LABOUR EXCHANGE, mentioning this Journal and F 473.

Two Mechanical Draughtsmen WANTED, experience in Factory repairs an advantage. No person already serving war purposes need apply.
See conditions G.B. Defence of the Realm Regulations.
State full particulars, age, and salary expected, to CADBURY BROTHERS, Ltd., E. N. A. Dept., Bournville. F 553

Civil and Mechanical En- gineering DRAUGHTSMAN WANTED, thoroughly experienced in preparing detail and arrangement plans, for the construction of Dry Docks, Dock Gates, and Pumping Arrangements.—Apply, stating age, experience, and if quite free for engagement, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 549. No application from anyone at present engaged on Government work, or eligible for the Army entertained.

Assistant Draughtsman WANTED, for Marine Auxiliary Machinery. State experience and wages expected. No person already engaged on Government work or residing more than 10 miles away need apply.—Apply by letter, to CAIRD & RAYNER, 777, Commercial Road, Limehouse, E. F 563

A Controlled Firm of En- gineers in London REQUIRE a Capable FOREMAN or Working ENGINEER, to supervise the erection of plant and carrying out of Contracts throughout the United Kingdom. Permanent appointment for the right man. One having previous experience of similar work preferred. Must be a capable mechanic, used to control of men, and be prepared to reside in London. No one eligible for Military Service or already on Government work considered.—Apply, stating age, experience, and wages required, to nearest BOARD OF TRADE EMPLOYMENT EXCHANGE, mentioning this Journal and No A 2598. F 530

Machine-Shop Foreman REQUIRED for electrical and hydraulic engineering works. Good and permanent position for capable man. No person employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 490.

Machine Shop Foreman for large Shop on Munitions, London district. Mass production, small engineering parts; experience with B. & S. Automatics, Jigs and Tools. No man already on Government work need apply. —Write in the first instance to nearest EMPLOYMENT EXCHANGE, stating age, experience and wages required, quoting No. A 2681. F 519

Foundry Foreman Wanted in malleable iron shop employing 80/100 hands on War work. No one at present engaged on War work need apply. — Applications, in writing, to nearest LABOUR EXCHANGE, quoting No. A 2526. F 515

Good Reliable Man, with initiative, capable of taking full charge of plant for crushing and preparing various Ores, Corundum, and suchlike. Munitions work. Permanent post if suitable. — Address, F 548, Offices of ENGINEERING.

Wanted, Thoroughly Com- petent and qualified Contractor's AGENT for Government work.—Address, stating age, experience, salary required, &c., F 531, Offices of ENGINEERING.

Costing Clerk (Ineligible), WANTED. No person already employed on Government work will be engaged.—Apply, your nearest BOARD OF TRADE EMPLOYMENT EXCHANGE, stating age, experience and salary, mentioning this Journal and F 536.

Roll Turner Wanted; must be thoroughly competent man for mills rolling sections in hard and mild steel and wrought iron. Applicants should state age, and give full particulars of experience. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and F 447.

Wanted Lady Tracers, or with experience in Detail Drawing, &c.; must be quick and accurate. No one employed on Government work will be entertained.—Please apply to the nearest EMPLOYMENT EXCHANGE, sending full particulars and sample of work, mentioning this Journal and F 550.

Engineering Pupil.—Vacancy with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 5321, Offices of ENGINEERING.

A Large Firm of Engineers, in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4280, Offices of ENGINEERING.

SITUATIONS WANTED.

General Manager (Qualified), Engineers, Builders, Contractors, &c., wide experience, DESIRES ENGAGEMENT, London district.—Write, *C. L.*, care of VICKER'S, 5, Nicholas Lane, E.C. F 522

Works Manager, (age 33) in Marine Engine Works, DESIRES CHANGE. Experience in shops, outside, and as chief draughtsman; honours B.Sc.—Address, F 557, Offices of ENGINEERING.

Works Manager (41) Engineer DESIRES APPOINTMENT. First-class experience in modern methods of production, repetition work, expert knowledge on labour-saving machine tools, Government work, organising abilities, tactful control of labour, strict disciplinarian.—Address, F 556, Offices of ENGINEERING.

Engineer (45), Extra First- class B.T. cert., Memb. Inst., N.A., 18 years' experience surveys and superintendence, DESIRES Running SUPERINTENDENCE. Surveys or Supervision new construction.—Address, F 545, Offices of ENGINEERING.

Engineer, M.A., M.I.M.E., expert at organising and general management, OPEN to POSITION, London district.—Write, "Z.R.659," care of DEACON'S, Leadenhall Street, E.C. F 538

Electric Power Plant Engineer experienced Chief Draughtsman, designer and erector, largest steam turbine practice, including buildings, requires responsible position at home or abroad. Highest credentials, ineligible.—Address, F 556, Offices of ENGINEERING.

Wanted by French Engineer with Diploma, and Certified Pilot, POSITION OF RESPONSIBILITY in Factory carrying out contracts for aeroplanes or kindred work.—Address, F 534, Offices of ENGINEERING.

A French Civil Engineer, with Diploma, DESIRES POSITION OF TRUST in manufacturing works as Supervising Engineer or Technical Correspondent; has had special experience with power presses.—Address, F 533, Offices of ENGINEERING.

Advertiser, Ineligible, first- class all-round training, 18 year's experience, mainly on electrical side, prominent record as engineer and manager, DESIRES POST giving scope for organising and engineering ability. State particulars and salary proposed.—Address, F 503, Offices of ENGINEERING.

Engineer, 30 years' Experi- ence technical, practical, commercial, legal. Machine design, switchgear, traction, construction. Thorough draughtsman, accurate erector. Contracting preferred.—F 546, Offices of ENGINEERING.

PATENT AGENTS.

Jensen and Son, 5576
CHARTERED PATENT AGENTS.
(Established 1867). British, Colonial, and Foreign Patents, and Trade Marks and Designs Registrations 77, Chancery Lane, London, W.C. Tel.: Holborn 1249.

John E. Raworth,
CHARTERED PATENT AGENT,
20/71, Queen Anne's Chambers, 4995
Tothill Street, Westminster, S.W.

PARTNERSHIPS.

Partners
Directors
Businesses
Factories
for these apply to
WHEATLEY KIRK, PRICE & CO.,
46, Watling Street, LONDON, E.C.
Albert Square, Manchester. 4994
26, Collingwood Street, Newcastle-on-Tyne.

WANTED, &c.

Advertiser, now Representing tool manufacturers, makers of lifting machines, of wood-working or metal-working machine tools, of industrial equipments and metal supplies; having 10 years' experience as traveller for important Paris firms, and excellent connections amongst large works, automobile factories, important mechanical engineering firms, naval shipbuilding yards, &c.; owning an office and a warehouse; having in his service agents in Paris and in the provinces, and dealing with a very large turnover,
DESIRES to ENTER into COMMUNICATION with British merchants, or well-established agents, or wholesale firms, to sell their goods in France, either from now or from the conclusion of hostilities. If possible, he asks that the British firms in question entrust him with a stock of their goods, if required, against a security.
Address, E. LAURAY, 12, Rue de Lancry, Paris, 10th Arrondissement. F 209

THE TORSION OF SOLID AND HOLLOW PRISMS AND CYLINDERS.

By Cyril Batho, M.Sc., B.Eng., Assistant Professor of Applied Mechanics, McGill University, Montreal, Canada.

§1. *Introduction.*—In a paper read before the British Association in 1915 and published in Engineering (October 15, 1915, page 392), the writer demonstrated that if any thin-walled cylinder or prism, either continuous-walled or of framework, is subjected to a twisting moment T, the total longitudinal shear S is given by the expression

$$S = \frac{T\,l}{2A}, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where l is the length of the cylinder and A the area bounded by the contour of its cross-section (not the area of actual cross-section). The application of this to a framed structure was considered in detail. It is the object of the present paper to consider more closely the case of the thin-walled cylinder or prism having a continuous boundary, to extend the method to solid and hollow sections, to obtain approximate formulæ for the torsion of rolled structural sections, and to criticise certain formulæ in general use for hollow sections.

§2. *Thin-walled Cylinders and Prisms.*—If the walls of a cylinder or prism subjected to torsion are thin, equation (1) may be used directly to find the distribution of shearing stress. Denoting the thickness of the walls by t, the average intensity of shearing stress q over a section of the walls normal to the contour at any point P, is given by

$$q = \frac{T}{2At}, \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Thus, if the walls are of uniform thickness, the average shearing stress intensity is constant and if of variable thickness, it varies inversely as the thickness. Since the walls are thin, the actual intensity of shear at any point is, in general, practically equal to the average intensity, and is thus given very approximately by equation (2). An exception to this occurs at the corners of a prismatic section. At any corner the stress is zero and thus the shear cannot be uniformly distributed in its immediate neighbourhood.*

Equation 2 may thus be applied to find the strength of any thin-walled cylinder or prism subjected to torsion. It appears from this that all sections of the same material, of the same thickness and having the same area A, have the same resistance under torsion. This does not mean, however, that thin tubes of all shapes are equally efficient when used as shafts. The amount of material for the same values of A and t obviously varies directly as the perimeter of the section, and thus the circle is the most efficient form. For example, a square tube having the same resistance under torsion as a circular tube of the same thickness will contain 1.128 times as much material.

The angle of twist may be found from a consideration of the work stored. This is equal to

$$\int \frac{q^2}{2G} \cdot dV,$$

where q is the stress at any element of the volume dV, G is the modulus of rigidity of the material and the integration is throughout the volume. It is also equal to $\frac{1}{2}\,T\,\Theta$, where T is the applied twisting moment and Θ the angle of twist. Thus

$$\Theta = \frac{2}{T}\int \frac{q^2}{2G} \cdot dV$$

But

$$qt = \frac{T}{2A}.$$

Therefore

$$\Theta = \frac{T}{4A^2G}\int \frac{dV}{t^2} \quad . \quad . \quad . \quad (3).$$

If t is uniform, this gives

$$\Theta = \frac{T\,P\,l}{4A^2\,l\,G} \quad . \quad . \quad . \quad . \quad (4)$$

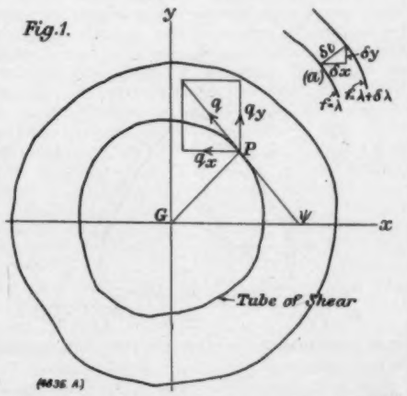
where P is the perimeter of the section and l the length over which Θ is measured.

* For a fuller discussion of this point, see a letter in Engineering, March 31, 1916, page 298.

There seem to be few experimental data on the torsion of thin-walled tubes, but the above receives striking confirmation from the experiments of Mr. Ritchie which were published in Engineering of January 21 and February 4, 1916. Mr. Ritchie used three hollow sections of the dimensions shown in Table I. It will be noticed that the ratio of width to thickness is not very great, so that the tubes can scarcely be called thin-walled. The angle of twist over a length of 5 ft. was measured for a twisting moment of 50 inch-lb. and the results are given in column 5. Column 6 gives the angles of twist calculated from equation (4). The modulus of rigidity was not measured experimentally for these cases, so that its value is somewhat uncertain. Mr. Ritchie assumed it to be 11×10^6 lb. per square inch, and this value has been used in calculating column 6.

Table I.

1	2			3	4	5	6	7	8
Type of Section.	Dimensions (inches).			Ratio of Width to Thickness.	Area of Section of Metal.	θ (exp.) in Degrees.	θ from Equation 4.	Difference (per Cent.)	Value of G for which Experimental and Theoretical Results Agree.
	Width.	Depth.	Thickness.						
									$\times 10^6$
Hollow rectangle	0.872	1.432	0.036	24.2	0.151	0.3245	0.3305	1.23	10.86
Hollow square ...	1.500	1.500	0.0502	33.4	0.296	0.0670	0.0923	6.09	11.68
Hollow oval ...	0.862	1.740	0.045	19.15	0.1788	0.3480	0.3668	5.40	11.60



It will be noticed that the agreement between columns 5 and 6 is within the range of experimental error and error in the evaluation of G. Column 8 gives the values of G for which the agreement would be exact. They are within the range of values given by Mr. Ritchie for those cases in which G was measured experimentally.

The above seems to show that reliance may be placed upon the method given for the calculation of stress and angle of twist even when the walls are not extremely thin, but further experimental evidence would be useful. It is interesting to note that Mr. Ritchie, applying the ordinary formula for a hollow elliptic section (Eq. 27 below) to the oval tube, obtains a result which is much too high. This he attributes to the actual section deviating from the elliptic. This may be so, but, even if the section were elliptic the formula would not give correct results, as it applies only to a section bounded by two similar ellipses and not to a tube of uniform thickness. This point will be considered later.

§3. *Extension of the Method to Solid Shafts.*—The shearing stress at any point within the cross-section of a solid shaft is tangential to one of a family of curves which may be called the lines of shear for the section,* the boundary of the section being itself a member of the family, since the stress at the contour must be everywhere tangential to the contour. Let Fig. 1 represent the cross-section, Gx and Gy being a pair of rectangular axes through its centroid G. The equation of the lines of shear may be taken as

$$f = \lambda,$$

where f is a function of x and y and λ a variable parameter, constant for any particular line of shear, the equation of the boundary being given by

$$f = 0.$$

The portion of the cylinder or prism bounded by two neighbouring surfaces of shear, of which the lines of shear are traces on the plane of the cross-section, may be called a *tube of shear*, and the whole shaft may be considered as made up of such tubes.

Now each tube of shear is under the same conditions of stress as a thin tube subjected to torsion, and thus equation (1) may be applied to it. Therefore,

$$q \cdot \delta t = \frac{\delta T}{2a} \cdot \quad . \quad . \quad . \quad . \quad (5)$$

where δT is the part of the twisting moment, T, carried by the tube under consideration, a is the area of the cross-section of the shaft bounded by the tube (not the sectional area of the tube), and δt is the normal thickness of the wall of the tube at the point where the shearing stress is q, *i.e.*, the distance between the lines of shear bounding the tube at this point.

The resultant shear q at P (Fig. 1) may be resolved into q_x and q_y parallel to Gx and Gy respectively. Thus

$$q^2 = q^2_x + q^2_y,$$

or

$$q = \frac{q_x}{q} \cdot q_x + \frac{q_y}{q} \cdot q_y.$$

But

$$\frac{q_x}{q} = -\frac{\delta y}{\delta t} \text{ and } \frac{q_y}{q} = \frac{\delta x}{\delta t},$$

where δx and δy are the components, parallel to the axes, of the thickness δt (Fig. 1*a*).

Thus

$$q \cdot \delta t = q_y \cdot \delta x - q_x \cdot \delta y \quad . \quad . \quad (6).$$

But, since q is tangential to the line of shear, $f = \lambda$, through P

$$\frac{q_y}{q_x} = \tan \cdot \psi = -\frac{\frac{\partial f}{\partial x}}{\frac{\partial f}{\partial y}},$$

where ψ is the angle of slope of the line of shear through P. This is satisfied by

$$q_x = -K\frac{\partial f}{\partial y} \text{ and } q_y = K\frac{\partial f}{\partial x} \quad . \quad . \quad (7)$$

where K is a constant.

But, if ξ, η; and ζ are the displacements, parallel to Gx, Gy and the axis of the shaft respectively, of the point P

$$q_x = G\left(\frac{\partial \zeta}{\partial x} + \frac{\partial \eta}{\partial z}\right) \cdot \quad . \quad . \quad (8a)$$

and

$$q_y = G\left(\frac{\partial \zeta}{\partial y} + \frac{\partial \xi}{\partial z}\right) \cdot \quad . \quad . \quad (8b)$$

where G is the modulus of rigidity of the material.

Now under shear the radius GP (Fig. 1) turns through an angle $\delta\,\theta$ which is the same for all points, and $\frac{d\,\theta}{d\,l}$ is constant along the shaft.

Thus

$$\xi = -kxz \text{ and } \eta = kyz \quad . \quad . \quad (9)$$

where k is a constant and z is measured along the axis of the shaft. Differentiating 8*a* with respect to y and 8*b* with respect to x and subtracting

$$\frac{\partial q_x}{\partial y} - \frac{\partial q_y}{\partial x} = c,$$

where c is a constant. Substituting for q_x and q_y from equation (7), assuming K constant,

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = -\frac{c}{K} = \text{a constant} \quad . \quad (10).$$

Thus, if K be constant, f must satisfy (10). This equation, combined with the condition that $f = 0$ at the boundary, suffices for the determination of f. It is now only necessary to find K. Substituting the values of q_x and q_y from (7) in equation (6),

$$q \cdot \delta t = K\left(\frac{\partial f}{\partial x} \cdot dx + \frac{\partial f}{\partial y} \cdot dy\right),$$

or, using (5),

$$\frac{\delta T}{2a} = K \cdot \delta f.$$

Integrating this over the whole cross-section,

$$T = 2K\int a \cdot df \quad . \quad . \quad . \quad (11).$$

* See Love, Theory of Elasticity, page 309.

But a is zero at the centroid and f is zero at the boundary. Thus, integrating by parts,

$$T = -2K\int f \cdot da, \quad . \quad . \quad . \quad (12)$$

the integral extending over the whole section. Thus, if f is obtained from equation (10), K may be found from equation (12), and the stress at any point of the section is then known from (7). The angle of twist Θ for a length l may be found, as in the case of the thin-walled tube, from

$$\Theta = \frac{l}{GT}\int q^2 \cdot da, \quad . \quad . \quad . \quad (13)$$

the integration extending over the whole section.

§4. *Examples:* (*a*) *The Solid Elliptical Shaft.*—Let the semi-major axis be b and the semi-minor axis h. Then the equation of the boundary is

$$\frac{x^2}{b^2} + \frac{y^2}{h^2} - 1 = 0.$$

Thus a possible value for f is

$$f = \frac{x^2}{b^2} + \frac{y^2}{h^2} - 1.$$

This would give

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = \frac{2}{b^2} + \frac{2}{h^2},$$

which is a constant. Thus the lines of shear form a family of similar and similarly situated ellipses, for which

$$\frac{x^2}{b^2} + \frac{y^2}{h^2} - 1 = \lambda.$$

Applying equation (12) to this case

$$T = -2K\int\left(\frac{x^2}{b^2} + \frac{y^2}{h^2} - 1\right) da.$$

But $\int x^2 \cdot da$ and $\int y^2 \cdot da$ are the moments of inertia of the section about the axes Gy and Gx respectively and $\int da$ is the area of the section. Substituting the values of these in the above equation,

$$K = \frac{T}{\pi b h}.$$

Thus the components of stress at any point of the section are

$$q_x = -K\frac{\partial f}{\partial y} = -\frac{2Ty}{\pi b h^3},$$

and

$$q_y = K\frac{\partial f}{\partial x} = \frac{2Tx}{\pi b^3 h}.$$

The maximum shearing stress occurs at the end of the minor axis and is given by q_x, on substituting $y = h$. Thus

$$q_{max.} = \frac{2T}{\pi b h^2} \quad . \quad . \quad . \quad (14).$$

For a circular shaft of radius r, $b = h = r$, and

$$q_{max.} = \frac{2T}{\pi r^3}$$

Thus the radius of a circular shaft of equivalent strength to the elliptical shaft is given by

$$r = \sqrt[3]{b h^2} \quad . \quad . \quad . \quad (15).$$

The angle of twist over a length l may be found from equation (13).

$$\Theta = \frac{l}{GT}\int q^2 \cdot da$$

$$= \frac{Tl}{G\pi^2 b^2 h^2}\int\left(\frac{x^2}{b^4} + \frac{y^2}{h^4}\right) da$$

$$= \frac{Tl}{G\pi} \cdot \frac{h^2 + h^2}{b^3 h^3} \quad . \quad . \quad (16).$$

For a circular section of radius r this becomes

$$\Theta = \frac{2Tl}{G\pi r^4}.$$

Thus a circular shaft of equivalent stiffness to the elliptical shaft has a radius*,

$$r = \sqrt[4]{\frac{2}{\pi}\frac{b^3 h^3}{b^2 + h^2}} \quad . \quad . \quad . \quad (17).$$

* It should be noted that shafts of different shapes having the same stiffness are not, in general, of the same strength, and thus the relative strengths of such shafts cannot be obtained from measurement of the angle of twist unless the law of variation of stress is known for each shaft. Mr. Ritchie seems to have fallen into this error in discussing the results of his experiments mentioned above. For example, the column of the table on page 50 (ENGINEERING, January 21, 1916), headed "Diameter of circular section of equivalent torsional strength," really gives the diameter of a circular section of equivalent torsional stiffness.

(*b*) *The Equilateral Triangular Shaft.*—Let ABC (Fig. 2) represent an isoceles triangle referred to axes Gx and Gy through the centroid, Gx being parallel to the base BC. If the length of BC is $6b$ and the height $3h$, the equation of the boundary is

$$\left\{\left(\frac{y}{2h} - 1\right)^2 - \frac{x^2}{4b^2}\right\}(y + h) = 0.$$

Thus the left-hand side of the above is a possible expression for f. This satisfies

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = \text{a constant},$$

if $h = \sqrt{3} \cdot b$, *i.e.*, if the triangle is equilateral. In this case the lines of shear will be given by

$$f = \left\{\left(\frac{y}{2h} - 1\right)^2 - \frac{x^2}{4b^2}\right\}(y + h) = \lambda,$$

and, applying equation (12),

$$T = -2K\int\left(\frac{y^3}{4h^2} - \frac{3}{4} \cdot \frac{y^2}{h} - \frac{x^2 y}{4b^2} + h - \frac{x^2 h}{4b^2}\right) da.$$

Now

$$\int y^2\, da = I_{Gx} = 4.5\, b h^3,$$

$$\int h\, da = 9\, b h^2,$$

$$\int x^2\, da = I_{Gy} = 13.5\, b^3 h$$

$$\int x^2 y\, da = \int_{-3b}^{0}\int_{-h}^{\left(1 + \frac{x}{2b}\right)2h} x^2 y \cdot dx \cdot dy + \int_{0}^{3b}\int_{-h}^{\left(1 - \frac{x}{2b}\right)2h} x^2 y \cdot dx \cdot dy$$

$$= -5.4\, b^3 h^2$$

and $\int y^3\, da$ may be found by integrating in a similar manner and is equal to $1.8\, b h^4$.

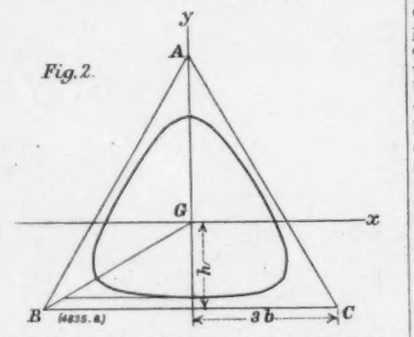


Fig. 2.

(4835.8)

Substituting these values in (18) and replacing h by $\sqrt{3}\, b$,

$$T = -24.3\, K b^3.$$

Thus

$$q_x = \frac{T}{97.2\, b^3}(y^2 - 2\sqrt{3}\, y b - x^2)$$

This suffices for the determination of the distribution of shearing stress along BC, since $q_y = 0$ along this side. The maximum stress occurs at the mid-point of each side, i.e., at the points of the contour nearest to the centroid, and is given by

$$q_{max.} = 20\,\frac{T}{S^2}, \quad . \quad . \quad . \quad (19)$$

where $S = 6b$ = the length of the side.

Thus the radius of a circular shaft of equivalent strength is given by

$$r = 0.317\, S,$$

and the weight of a triangular shaft is 1.37 times the weight of a circular shaft of the same material, length and strength.

At the corner C, $x = 3b$, $y = -h$. Thus $q_x = 0$. The stress parallel to the side AC is also zero. Thus the stress at the corner is zero. The distribution of stress will, of course, be the same along each side.

The shape of the lines of shear is indicated in Fig. 2.

The angle of twist could be calculated as in example *a*, but the analysis, although not difficult, is too long to be given here.

The above examples will suffice to show the application of the method. In most of the other cases f takes a complicated form and the analysis is much more difficult. The results obtained are, of course, the same as those arising from the usual methods of analysis, but it appears to the writer that the above method is simpler, the mathematics involved more elementary, and the physical conditions kept more in evidence.

(To be continued.)

THE CLASSIFICATION OF RAILWAY FAILURES.

WHILST a moderately good idea of the efficiency of a railway can be obtained by referring to statistics of its train delays, it must be borne in mind that some railways are handicapped by special difficulties, such, for instance, as may be occasioned by abnormal weather, or by a flow of traffic in one direction, or by limited finances, and that these difficulties have a direct bearing on the failure returns. In order that the statistics may form a basis of comparison the delays or failures must be carefully analysed in order to extract those which could have been avoided, and in doing so the limitations of the railway to deal with the aforementioned embarrassments must be duly taken into consideration.

Every failure, whether traceable to the traffic, locomotive, engineering or signalling department, can be classified under one of two headings—viz., "avoidable" or "unavoidable"; and if all railways were equally well equipped and subjected to identical conditions, the classification could be readily achieved. This, however, is far from being the case. A railway in its infancy, striving to pay its way and consequently provided with the irreducible minimum of staff, is unable to devote the same amount of attention to precautionary measures for forestalling failures as does a more flourishing concern. On pioneer railways, where the employees are drawn from an uncivilised population, on which years of training must be devoted before the most elementary principles of efficiency can be inculcated, some allowance must be made for the incompetency of the subordinate staff and a liberal view must be taken of the failures that occur. For such reasons the dividing line which separates "avoidable" and "unavoidable" failures is arbitrary, and can only be fixed by one who is thoroughly acquainted with the railway itself, and knows exactly the limitations of the staff, material, &c., with which it is equipped.

A severe critic, investigating failures without considering the extenuating circumstances peculiar to the railways on which they occur, would assume that every mishap is avoidable unless it is caused by unprecedented atmospherical conditions, or by an unlooked-for rush of traffic such as would be occasioned by the transport of troops following a declaration of war. In short, he would hold somebody responsible for every failure unless traceable to exceptional conditions, which, on account of their singularity and intensity, could have not been anticipated or provided against.

If materials could be guaranteed flawless and the human element infallible, it is conceivable that this idealistic measure of efficiency might be insisted upon. Its enforcement, however, would involve a large and unprofitable expenditure, as the maximum traffic requirements—no matter how short their duration—would be taken as the standard on which to base the equipment of the railway, and, consequently, during slacker seasons the railway would be overstocked with locomotives and vehicles, over-provided with signal-cabins and overmanned with employees, all of which would represent idle capital.

Fortunately, the administration of a railway does not allow itself to be influenced by the idealist. Being a commercial concern, it recognises that the elimination of failures is expensive, and that money spent for this purpose, if carried beyond a certain point, will bring no return at all. It therefore insists on the standard of efficiency for which it pays, and consequently classifies all such failures as do not fall within these limits as "unavoidable." On one railway a delay to a train may lead to serious consequences, whilst on another it may be of no account at all, and one may well forgive the directors of the latter for disregarding expensive proposals which have nothing better to recommend them than a purely sentimental aversion to failures. To illustrate the point, imagine the

system of periodical examination which is in vogue in the locomotive department of an English railway being enforced with the same scrupulousness on a single track conveying one train daily through an uncivilised country in the wilds of Africa. Yet, if the failures occurring on these two systems are to be judged from one and the same standpoint, it is only right that the means adopted for their circumvention should be identical.

For purposes of comparison failures should be recorded on a mileage basis. Then it will be found that, as a rule, a railway with a big mileage shows to advantage. Such a railway is usually—but not necessarily—a paying concern which has reached an advanced stage in its evolution, and this stage has only been acquired by catering to public demands, which have become more and more exacting with time. Thus in the development of a railway an inducement to eliminate failures is generated, and the incentive—viz., an ever-increasing number of fastidious passengers—automatically provides the capital necessary for their elimination.

If a comparison be drawn between an English and a Colonial railway, the superiority of the former in regard to its failures is at once apparent. The fact, which is frequently disposed of with an airy reference to the higher grade of perfection to which its employees have been trained, is often traceable to conditions existing on the latter railway which, to overcome, would necessitate an expense out of all proportion to the earning capacity.

Among such conditions may be instanced the necessity, common to many Colonial railways, of ordering their locomotives and rolling-stock from European firms. This may be effectively done if the order is accompanied by a complete set of working drawings, and if the reliability of the materials is covered by specifications whose terms are enforced by inspecting engineers specially employed for that purpose. Unfortunately, however, many railways are not in a position to pay for such elaborate safeguards, and their orders are often accompanied by diagrammatic sketches which merely specify the principal dimensions.

It is to this somewhat casual method of ordering that many failures are attributable, the reason being that, whilst the main dimensions of a machine rule its power and capacity, its serviceableness is dependent on the design of its details. A locomotive may completely satisfy the terms of a brief specification which merely stipulates the maximum power that is required of it, and, incidentally, an intelligent student, with a good working knowledge, is quite capable of placing the order, but when subjected to the exacting conditions of regular train service it may well prove a constant source of trouble.

A manufacturer, however anxious he may be to satisfy his clients, is handicapped by the lack of experience which is derived from service conditions, and if the design of the details is left entirely in his hands, he naturally works to his own standards. If, therefore, it subsequently transpires that his working parts are too complicated or otherwise unsatisfactory for a semi-civilised race, one can scarcely blame him for following a course which, for want of a better, was dictated by economy and speed of production.

An English railway builds its stock to complete sets of working drawings, wherein the details receive as much attention as the general arrangements. The designs are the ultimate result of many years of experience. They are not hastily conceived, but have been gradually evolved, and their evolution has been influenced by a desire to eliminate the defects revealed by service conditions. Therein lies an advantage over a vast number of Colonial railways and an explanation for the differences in their relative failure returns.

It is interesting to note upon what very slight considerations a failure, originating in the designer's office, may depend. An oil-way too narrow to supply sufficient lubricant, the diameter of a bolt too small for the stress imposed upon it, the absence of locked nuts and split pins, the use of one material where another would have been more satisfactory, are well-known illustrations. But trivial as they are, merely requiring a few minutes' deliberation by an expert and the stroke of a draughtsman's pencil to rectify them, they may entail a great deal of labour if the alteration is to be effected after the work has been completed.

The administration of a pioneer railway may well argue that it requires more than the stroke of a pencil to eliminate failures due to design, that, in fact, it necessitates a whole batch of carefully thought-out and fully dimensioned working drawings, and that it cannot obtain locally nor afford to import from abroad men of sufficient ability to prepare them; in short, that it is preferable from a financial point of view to order casually and risk the results. The plea is feasible, and mishaps on such a railway must be judged, *i.e.*, classified as "avoidable" or "unavoidable," more leniently than those which occur on a railway which builds its stock to full working drawings. Nevertheless, as a large proportion of mishaps are attributable to defective design, the practice of ordering to detail drawings is to be commended.

It is an unwritten law that when a locomotive which is not labelled an experiment is put into service it is assumed to be a thoroughly efficient and workable machine, and that any "avoidable" failures occurring after the completion of its trial trips are debitable to some employee in the running department. The principle is justified on the ground that a locomotive, having once performed its work satisfactorily, should, if properly attended to, always do so; it works well in practice because it induces sharp supervision, which reacts on and promotes the efficiency of the subordinate staff; also its application is encouraged by the fact that a delinquent can be readily traced. It is, however, unsound. The responsibility of a failure is usually nailed to one man whose carelessness is obvious, but it is frequently shared by others whose participation is not so manifest, and who therefore remain in obscurity. Suppose, for example, the wash-out plugs of a boiler are situated in such ill-chosen positions that they require specially shaped spanners to remove them, and, after removal, necessitate the use of hose-pipes with specially curved nozzles. Can one entirely blame a harried shed-man if he postpones their withdrawal until next time? It is only reasonable that the designer who overlooked or ignored the importance of readily accessible wash-out plugs should be held partly at fault for failures due to the boiler being indifferently washed out, but it is seldom that he is.

The designer's responsibility is usually shared with that of a less important employee whose fault is so glaring that it obscures the fundamental evil. It may, however, be detected by an infallible test—to wit, its continual reappearance on the failure returns. In short, if the same mishap reoccurs frequently, the design is defective, and prompt steps should be taken to remedy it. To urge in extenuation that the employees are untutored or incompetent is mere cavilling, for if a machine is designed for the use of an uncivilised race it should be "fool-proof."

Failures may be due to mismanagement on the part of any official, from the man earning two pounds a week to the man earning forty, but it will be found that the more senior the delinquent the more difficult it is to fix his responsibility, and the more easy it is for him to evade it. Reverting to the illustration of the wash-out plugs, the shed foreman who failed to call immediate attention to their ill-chosen positions, and the superintendent who, having had his attention drawn to them, failed to take prompt steps to alter them, would both be partly responsible for failures due to the boiler being badly washed out, and yet it is probable that they would both justify themselves by nailing the blame on the more obvious defaulter, *i.e.*, the unlucky shed-man who neglected to remove the plugs.

Locomotives are sometimes appointed to trains which they are not capable of working to the tabulated time. It may be that they are not sufficiently powerful to haul the loads; possibly they are designed for a totally different class of work to that which is required of them, or it is conceivable that the capacities of their tenders may be insufficient for the long non-stop runs laid down for the trains allotted to them. The result is the same. The unsuitability of the engine invites the consequent delay, and the locomotive department disposes of it by claiming a shortage of engine-power.

If a running-shed is denuded of its locomotive power, there is a strong inducement to despatch "unsuitable" engines, but it does not follow that the administration of the shed has proved its resourcefulness. On the contrary, if an engine which is appointed to a train with which it is not qualified to deal is subsequently returned light to its shed, indicating thereby that the traffic is unbalanced, one may unhesitatingly blame the shed foreman for failing to requisition a suitable engine in the first place.

When the traffic is balanced, however, the question of despatching "unsuitable" engines is more involved. The shed foreman is called upon to decide whether he is justified in applying for engines which are qualified to deal with the traffic requirements, knowing that by so doing he will be answerable for the light mileage, or whether it is preferable to appoint engines which, by reason of their size or design, are foredoomed to lose time. On the one hand he entirely meets the traffic requirements, but involves the administration in the cost of light mileage, whilst, on the other hand, he supplies an engine at a minimum cost, but perpetrates a delay to its train.

Now the late running of a train is liable to have very far-reaching effects. If the traffic is congested it will retard the following trains, and they in their turn will react on the branch line services with which they connect. Moreover, the initial delay, which was possibly reckoned in minutes, will probably increase during its transmission to other trains; so that the arrivals of the latter may be delayed hours after their scheduled times. The extent of the dislocation caused by late running is directly dependent on the heaviness of the traffic, and therefore the inducement to insure against delays varies in the same way. Consequently it may well be in the interest of a busy railway to pay for light mileage rather than deal with the chaotic state arising out of a delay. This fact goes a long way towards disposing of the aforementioned dilemma which a shed foreman is sometimes called upon to face. The question as to whether or not he should requisition light engines does not depend upon his unaided judgment, but rather upon a policy which should be dictated to him by those who are in a position to know what is best in the interest of the railway.

Failures, therefore, which are due to the appointment of unsuitable engines exemplify the rule, already enunciated, that they can only be classified by one who is intimately acquainted with the conditions regulating the administration of the railways on which they occur. On some railways they should be considered "unavoidable," whilst on others they should be condemned.

It follows, then, that failure statistics cannot be compared owing to the varying conditions existing in different countries and on different railways. The civilisation of the employees, the quality of the equipment, natural phenomena peculiar to the country, the extent of the inducement to seek perfection, and the financial ability to promote it, are all considerations which fix a separate standard of efficiency for each railway. Such being the case, it devolves upon the principals of the various departments to discover exactly what that standard is, and to enforce it strictly and fairly, always bearing in mind that moderation is as much against the interests of the company as over-rigorousness is unjust to its employees.

PASSENGER LOCOMOTIVE FOR THE CALEDONIAN RAILWAY.

We publish this week on page 500 and on Plate XLII engravings of a new type of passenger locomotive which has recently been placed in service on the Caledonian Railway. Of these engines, which have been designed by Mr. W. Pickersgill, the locomotive superintendent of the line, sixteen have been recently constructed, six being built at the St. Rollox Works of the Company, and the remainder at the Atlas Works of the North British Locomotive Company, Limited, Glasgow.

As will be seen from our illustrations, the engines are of the 4-4-0 type, a type which is likely to be used

PASSENGER LOCOMOTIVE (4–4–0) FOR THE CALEDONIAN RAILWAY.

CONSTRUCTED FROM THE DESIGNS OF MR. W. PICKERSGILL, LOCOMOTIVE SUPERINTENDENT.

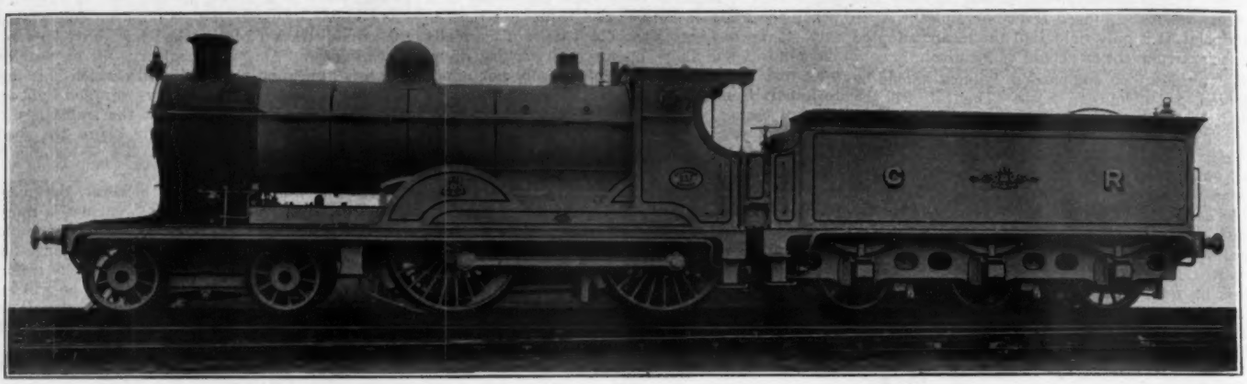


FIG. 3.

for working the bulk of the ordinary passenger traffic of this country for many years to come, although for specially heavy work the 4–6–0 type is now indispensable. The new Caledonian engines are of simple and pleasing design, while the proportions of the details are very substantial and practically reach the limit of size and weight for this class of locomotive.

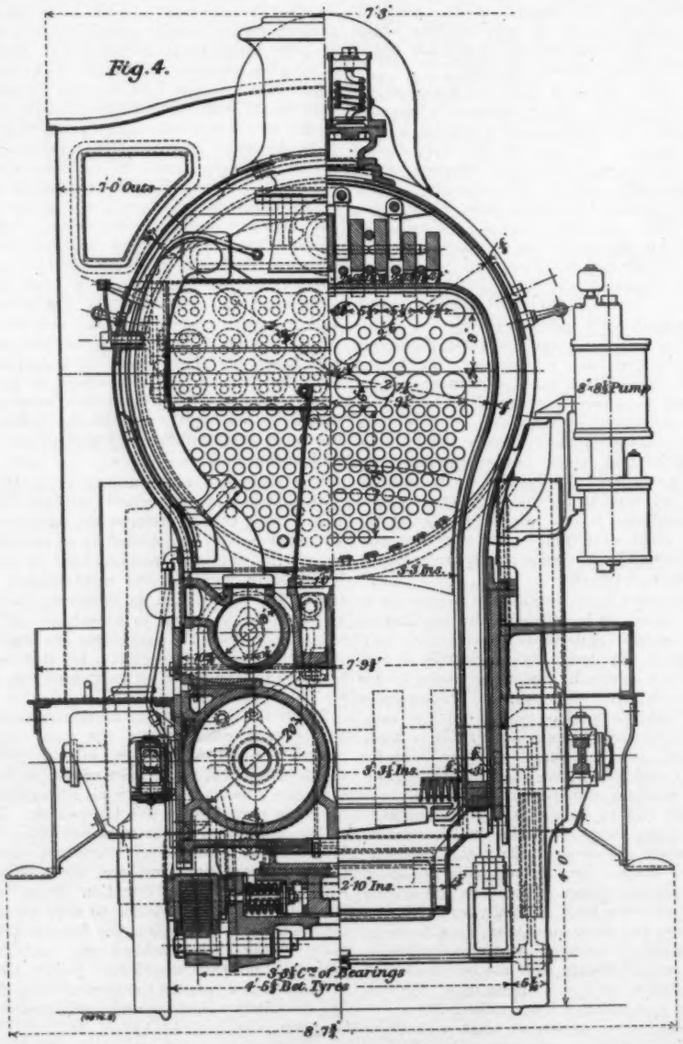
The chief particulars of the engines, &c., are :—

Cylinders :	
Diameter	1 ft. 8 in.
Stroke	2 „ 2 „
Wheels :	
Diameter of coupled wheels ...	6 „ 6 „
Diameter of bogie wheels ...	3 „ 6 „
Diameter of tender wheels ...	4 „ 6 „
Wheel base of engine	24 „ 4 „
Wheel base of engine and tender	46 „ 8½ „
Boiler :	
Heating surface of fire-box ...	144 sq. ft.
Heating surface of tubes ...	1185 „
Heating surface of superheater elements	200 „
Total	1529 „
Firegrate area	20.7 „
Tender, &c. :	
Water capacity	4200 gals.
Coal capacity	6 tons
Weight of engine in working order	61 tons 5 cwt.
Weight of tender in working order	46 tons 10 cwt.
Tractive force with mean cylinder pressure, 80 per cent. of boiler pressure	18,133 lb.

The engines have cylinders 20 in. in diameter with 28-in. stroke, these being placed horizontally with piston valves above them, as seen in Fig. 4. The piston valves are 9 in. in diameter, and owing to their position they have to be driven through a rocking shaft. The valves which have inside admission, are driven by link-motion of the Stephenson pattern and, owing to the introduction of the rocking shaft, the eccentric rods are "open." Steam reversing gear is used in combination with the ordinary hand lever. Automatic by-pass valves are provided connecting the two ends of each cylinder, and these are found to quite eliminate "knock" when running without steam, and to be otherwise advantageous. As will be seen from the plan, Fig. 2, the piston rods are extended through the front cylinder covers.

The frames are 1½ in. thick and are 4 ft. 1½ in. apart for the greater part of their length, but are closed in to 3 ft. 9 in. apart at the front buffer beam, so as to give clearance for the bogie wheels. The frames are well braced transversely, the connections including the cast-iron footplate at the trailing end. The horn blocks are of cast steel and are fitted with adjustable wedges. The coupled wheels are 6 ft. 3 in. in diameter, and the crank axle is 9½ in. in diameter at the wheel seats, and has journals 9½ in. in diameter by 9 in. long, while the crank-pin bearings are also 9½ in. in diameter and are 4½ in. long. In the case of the trailing axle the diameters are 9½ in. at the wheel seats and 8½ in. at the journals, the latter being 12 in. long. There is nothing unusual in the arrangement of the bogie, but it has a long wheel base, namely, 7 ft., and a total side play of 2½ in., features tending to produce easy running. The bogie wheels are 3 ft. 6 in. in diameter and their axles have journals 7½ in. in diameter by 10 in. long. The bogie pin is placed 1 in. in advance of the centre of the distance between the two axles.

Fig. 4.



As will be seen from our engravings and the general tabular statement of chief particulars annexed, the boiler is of ample size. It is fitted with the Robinson superheater, already fully described in our columns, and is made for a working pressure of 170 lb. per square inch. The superheater elements are made with short return tubes in order to obtain greater efficiency with less weight. On the engines built by the North British Locomotive Company the safety valves form a group of four, but on each of those built at St. Rollox two of Ross's patent 2½-in. safety valves have been fitted. Five of the engines so far built are fitted with the Vacuum Detroit sight-feed lubricator and the remaining eleven with the Caledonian Railway mechanical lubricator with ten feeds. The method adopted for driving this lubricator is shown on the

PUNCHING MACHINE WITH ELECTRICALLY CONTROLLED GAG.

CONSTRUCTED BY THE HILLES AND JONES COMPANY, ENGINEERS, WILMINGTON, DELAWARE, U.S.A.

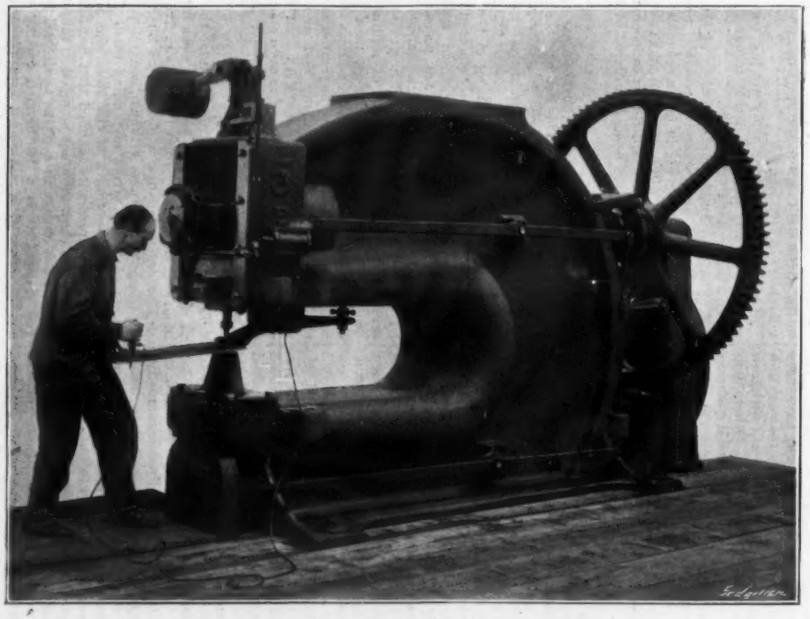
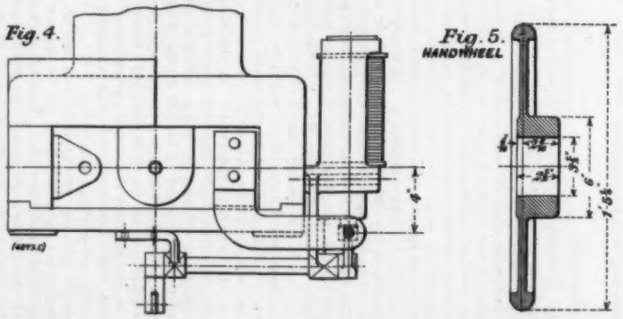
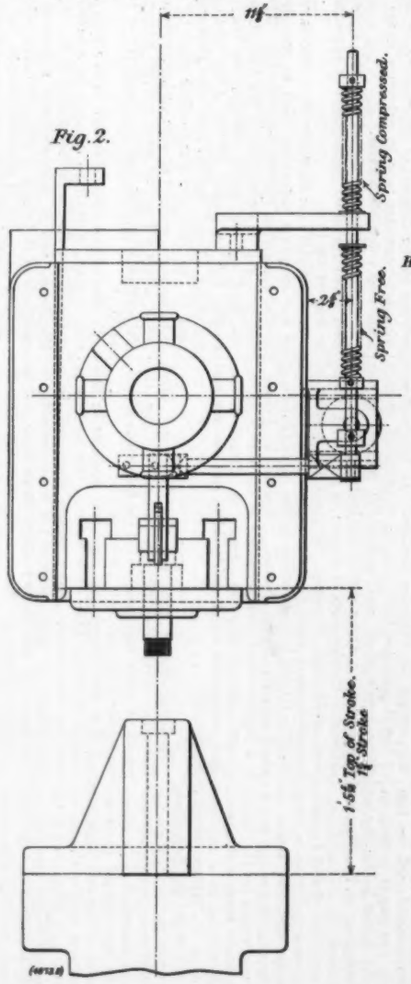
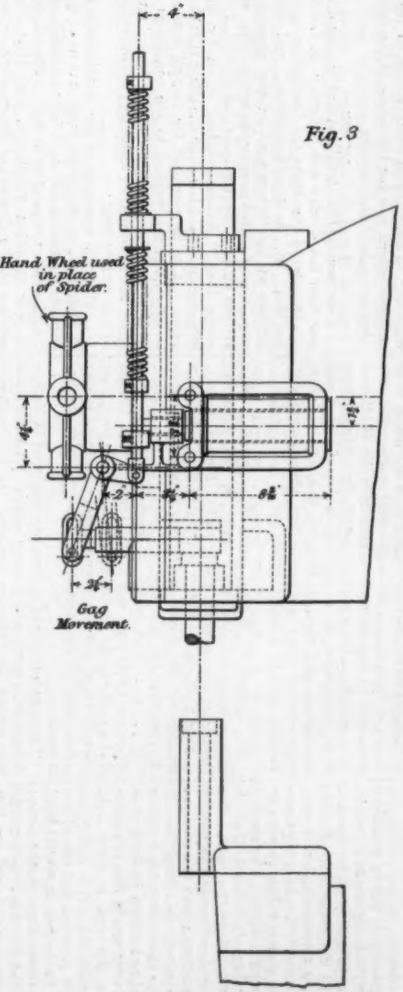


FIG. 1.







plan, Fig. 2, from which it will be seen that the lubricator lever is actuated by a connecting rod coupled to a return crank fixed to the end of the driving crank-pin on the right hand side of the engine. The pin of the return crank has a throw of about 2 in., and as this throw is constant an invariable feed of oil is obtained.

The engines are fitted with the standard Westinghouse brake, but are also fitted with a vacuum brake ejector and train pipes, to enable them to be used with trains fitted with the vacuum brake. As will be seen from Fig. 3, the general lines of the cab, splashers, and smoke-box are distinctly "Caledonian," although some changes may be noticed, such as the absence of wing-plates on the smoke-box sides, and the new style of cab-doors, opening inwards.

The adoption of superheating and the consequent economy of coal and water has had its effect on the design of the tender, and with less weight to carry Mr. Pickersgill has not hesitated to adopt the six-wheeled type in place of the eight-wheeled type with double bogies, and has so saved some 5 to 6 tons of dead weight. The tank capacity is 4,200 gallons, and there is space for 6 tons of coal. To carry this weight of water and fuel it was of course necessary to provide the axles with large journals, and these have been made 7½ in. in diameter by 12 in. long.

The engines we have described are employed in working express passenger trains on the Caledonian main line, in the Southern division to Carlisle and in the Northern division to Dundee, Perth and Aberdeen.

PUNCHING MACHINE WITH ELECTRICALLY CONTROLLED GAG.

WE illustrate above a heavy deep-throated punching machine fitted with an electrically controlled gag. This machine is constructed by the Hilles and Jones Company, of Wilmington, Delaware, U.S.A., whose English representatives are the E. W. Bliss Company, Pocock-street, Blackfriars-road, London. These machines are made in a large range of sizes, and have found much acceptance in the shipyards and structural shops of America. The recorded capacity of one of the large bridge shops in the United States with these machines shows a capacity of over 500 holes per hour, this being the hourly actual average of holes punched during nearly 20 hours, and not a performance during a short spurt. During the

period named one hole was punched at a time on irregular, large and heavy plates.

On reference to the illustrations it will be seen that the man holds in his hand a switch, by means of which the machine is put in and out of operation as desired, the switch being connected to the mains by a flexible conductor. The machine runs constantly, but it only punches when the circuit is completed. At other times the punch slides up into the punch holder as soon as it strikes the plate and no work is done. The current controls a solenoid, shown in Figs. 1, 2, 3 and 4, which is arranged horizontally at the side of the head. The core of this solenoid is pressed outwards continually by a spring, and is only withdrawn into the position shown in Fig. 3 when the circuit is complete. At all other times the head of the solenoid stands between the two collars on a vertical rod shown in front of it in Figs. 2 and 3, and as it very nearly fills the space between these two collars the rod is then held stationary. This rod is connected by a bell-crank lever (Fig. 3) to a gag, which slides in and out of the punching head. When it is in the gag is on the head of the punch and forces it down through the plate; whereas when the gag is out the punch is free to recede as already described. If the vertical rod be free from the core of the solenoid, the gag is pushed in and out at every stroke of the punch holder by an arm carried on the top of the holder and actuating the rod connected to the bell crank.

At the upper part of this rod (Figs. 2 and 3) there is a spring which is in compression during a very considerable part of the stroke, and this spring is always trying to force the gag home. Below the arm is a second spring, which comes into action for the lower half-inch of the stroke of the punch head, and serves, together with the weight of the rod, to force the gag out of the operative position at the bottom of the stroke at the instant the pressure of the punch against the gag is relieved, that is, when the head starts up and the punch begins to be pulled or stripped from the work. When the solenoid is not energised the vertical rod is held stationary, and the two springs have to give way to permit of the motion of the arm mounted on the punch head. The moment that the solenoid is energised and the head of the core withdrawn from between the two collars, the gag is forced forward by the upper spring into the operative position and the hole is then punched. As the punch is being withdrawn the gag is moved upwards by the lower spring, and the head of the solenoid core slips in between the two collars and holds the gag in the inoperative position until the man again presses the switch and completes the circuit. It will thus be seen that the punch is under the complete control of the operator; he can put the plate into the exact position he desires, and adjust it accurately, and then when he presses the switch the punch comes down and makes the hole. By this means great accuracy can be attained, with a remarkable amount of speed.

INDUSTRIAL NOTES.

In proposing a vote of thanks to Dr. Dugald Clerk, D.Sc., F.R.S., for the address he delivered to the Royal Society of Arts on the 15th inst. (see page 487 *ante*), Sir Robert Hadfield stated that if the British people were true to themselves, the nation would continue to expand and have a larger share in the concerns of the world than they had had in the past. He, Sir Robert, also hoped that a forty-eight hour week would be established. Sir George R. Askwith, who seconded the vote of thanks, said it had been his duty during the last two and a half years to deal with very large increases of wages, amounting in nominal value to millions upon millions of pounds and affecting hundreds of thousands of human beings. At the beginning of the war, he added, it was feared that in certain sections of trade there might be a great amount of unemployment and a great loss of wages. That fear had not come true, but it was some time before the doubt was dispelled. It was possible that at the end of the war a period of doubt, hesitation and adjustment might again ensue; but after that, and even during it, he looked forward to a period of production and of the necessary reinforcement of the waste that had taken place, which would lead to an increase of, or at any rate to the maintenance of, wages, and the desire to maintain these wages would also lead to an increase of production. It had been a very bitter thing indeed, Sir George Askwith said, for many trade unions to give up rules, regulations and ideas they had been working for during a quarter of a century or more, but some of them had adjusted those rules and regulations in a surprising manner, and where they had done so upon right lines the result had been to the satisfaction of most of the members. He doubted whether some of the unions would ever go back to the policy and to the rules which existed before the war. In regard to female labour, he stated that if women were to go into an industry other than that connected with munitions, where wages were at present high, it would be necessary for the employers in different branches of industry to realise that women were not likely to be drawn to them unless the wages were made sufficiently attractive to induce them to give up a life of idleness or to withdraw from pursuits which they liked better. It was necessary, he concluded, to look forward and to organise, and then, he thought, this country would maintain the great position it had already achieved, and rise even to a higher plane.

Mr. Joseph G. Butler, junr., Youngstown, Ohio, who represented the steel trade in the American Industrial Commission which visited France, arrived at New York on the return journey of the Commission on October 29. From his report, issued in the *Iron Age*, we take the following:—

". . . The labour in French iron and steel plants is paid very much less than in the United States; in many instances one-half and even less. There are very few disturbances, and dictatorial labour unions such as we have in the United States are unknown.

"A large number of women are employed in France doing men's work, which keeps wages at a lower level than would otherwise be possible. All the members of the Commission have seen in their travels women doing men's work and performing manual labour which in our country would not be thought of for a moment. Employment of women in steel and munitions plants has, of course, increased the number of women workers since the war commenced. This, I think, is largely brought about by the patriotic feeling which prevails all over France. 'Working for France' is a slogan rooted and imbedded in the minds of the people, whether they are soldiers or engaged in any other occupation which may tend to end the war and save France. . . ."

Speaking before the American Iron and Steel Institute, on October 27, Mr. Elbert H. Gary, the president of the Institute, stated the following, according to *The Iron Age*, New York:—

"It is well known that the steel business in this country is better than ever before. Our concern is only for the future. Many believe there will be a continuance of large business for many months or years after the war closes; others think there will be a material recession. No one can certainly foretell. Obviously, the wise man will husband his resources, keep within safe limits and avoid over-extension.

"Whenever the war shall close, the business of this country will be confronted with new conditions. The purchasing power of the whole world will have been very greatly reduced. Foreign countries that are now buying our products, because compelled, will withdraw their patronage in a large measure. Other, non-producing, countries will find their financial resources and credits lessened. Foreign producers, in great need, will strive more diligently than ever to supply the countries that are financially able to pay, and at prices based upon cheap labour and low cost, as they have a perfect right to do.

"Our producers, including our wage earners, will find themselves in commercial antagonism with the most persistent and difficult competition ever experienced, unless this shall be prevented by laws that are reasonable and sufficient. Most of the foreign producing countries, and quite likely all of them, will be thoroughly protected by tariff provisions, and we should be on a parity with them in this respect.

"I firmly believe, if the present unprotective tariff laws remain unchanged, we shall probably meet with competition from foreign sources after the war closes which will adversely, and perhaps disastrously, affect American industry and labour.

"If the laws are amended and adequate protection is afforded to the American producers and their workmen, we may expect satisfactory business conditions for some time to come."

On the occasion of the same meeting Mr. C. M. Schwab predicted that, following the present unprecedented prosperity for American industry, a period of financial depression would come upon the United States in the next five or ten years, and that this would bring an entire commercial and financial readjustment which would serve to teach economy to the American people.

We read in *La Métallurgie* that a French company, to be known as "Le Matériel Roulant," is being formed in Paris for the installation of new works and the organisation of existing works, with a view to the manufacture of railway and tramway rolling-stock and of the material required for all transport over land. The promoters belong to the largest French engineering establishments. After the war, states our contemporary, it will be necessary to manufacture in large numbers both engines and wagons, and these will have to be produced rapidly and at as low a cost as possible. If practicable, a commencement will be made before the close of hostilities. It will be the aim of the new company to standardise manufacture to the greatest possible extent and for the whole of the rolling-stock used throughout the country.

A conference of the Amalgamated Society of Engineers was held last Friday and Saturday, in London, with the Minister of Munitions, the Under-Secretary of State for War, Mr. Austen Chamberlain, and the Labour Adviser to the Government on the question of the recruiting of skilled men for the army. The agreement arrived at with the Amalgamated Society of Engineers states that "the undertaking given by the Prime Minister on September 28 to the effect that skilled men ought not to be recruited for general service will be strictly observed, subject to the conditions attached to it by the Prime Minister at the time," and it proposes the following, in order to give immediate effect to this undertaking:—

1. That all members of the Amalgamated Society of Engineers, as one of the trade unions of the skilled engineering trades not now fully engaged, or at any time hereafter ceasing to be fully engaged, shall enrol as war munition volunteers, and thus place their services at the disposal of the country, in accordance with arrangements now in existence under the war munitions volunteer scheme.

2. The skilled men referred to in this agreement are men who were either journeymen or apprentices prior to August 15, 1915.

3. All skilled men on war work or who have enrolled as war munition volunteers shall be provided with a card of exemption from military service. The form of this card will be authorised by the Army Council, and the card will be issued through the trade unions. Orders will be issued by the Army Council to all recruiting officers that no man who produces such a card to the local recruiting officer shall be removed from his work without specific authority from the War Office, which will not be given without reference to the Minister of Munitions and the executive of the men's union.

In case of any dispute arising as to a man's right to hold a card, it shall be decided by a representative of the War Office, a representative of the Ministry of Munitions, and a representative appointed by the executive of the union to which the man belongs.

4. The provision of skilled mechanics for the army will in future be made by the Ministry of Munitions.

The trade unions will do their utmost to provide the Ministry of Munitions with skilled men, who will undertake to serve at the choice of the Ministry either in the Artificers' Corps in the army or as war munition volunteers in civil life.

If skilled men for the army are not secured in this way it is clearly understood that recourse must again be had to the statutory powers.

5. That the Amalgamated Society of Engineers will furnish names, and, wherever possible, particulars of skilled men now serving in non-mechanical corps, and the Army Council will continue to make every possible effort to transfer such skilled men to mechanical units.

The same points are being considered with the other skilled engineering unions.

A revised list, R. 105, of certified occupations has been issued by Government. The list has been prepared, and the ages (which have been generally raised) fixed after careful inquiry into the industrial needs of the country. The reservations it contains will be reduced early in 1917 by a further raising of the age-limits, especially in the trades not mainly engaged on Government work. Employers in certified trades should therefore take such steps as are practicable—says a notice attached to the list—to reorganise their staffs, by substitution or dilution, with a view to being prepared to release more men of military age and fitness for the army. At present, men in certified occupations who are under the age-limits stated in the list are nevertheless entitled to be treated as covered by the list if found by a Recruiting Medical Board to be unfit for general service (Category A). In the next list this arrangement will be altered so as to make available for the army men found fit for garrison duty abroad (Category B).

Lord Dewar, Judge of Appeal under the Munitions of War (Amendment) Act, gave last week his judgment in an appeal made by John Preston and five other men of Rutherglen, against a decision of Sheriff Fyfe, in the Glasgow Munitions Tribunal, convicting the men of taking part in a strike and fining them 1*l.* each for contravening Section 2 of the Munitions of War Act, 1915. The appellants claimed that Section 2 did not apply, since they were not engaged in munitions work and did not engage in a strike as defined by the Act. The respondent is a Rutherglen carting contractor, not the owner of a controlled establishment, but engaged in carting coal and raw materials to a controlled establishment; the appellants were solely employed in this carting work when the strike took place. Lord

Dewar dismissed their appeals, and at the close of his judgment he recommended all workmen who may be in doubt as to their position to submit any differences which may arise to arbitration, and to refrain from a strike; a strike, he added, may bring them serious trouble and cannot in any case be effective.

It has been decided between Mr. W. F. Roberts, vice-president of the Bethlehem Steel Company, and the Superintendent of Public Schools of South Bethlehem, says *The Iron Age*, New York, to add a four-year industrial course to the regular high-school curriculum. Students will study part of the day in the steel company's various departments so as to gain practical knowledge. Henceforth, boys can stay in school and simultaneously serve an apprenticeship in any department of the steel works for which they have a "bent," receiving wages at the same time.

With reference to the renewed unrest among the South Wales miners, it is interesting to put on record a few notes taken from *The Times*:—The figures of the average selling price of coal f.o.b. at the South Wales seaports, ascertained by the joint auditors appointed by the proprietors and the men, and accepted by both parties as the governing factor in questions of wage rate alterations, are as follow:—

	Quarter Ended June, 1914, per ton	Quarter Ended June, 1916, per ton
Large coal ..	17*s.* 1.36*d.*	24*s.* 8.50*d.*
Small coal ..	9*s.* 4.16*d.*	16*s.* 7.45*d.*

These figures show an average increase per ton of coal sold by the collieries represented in the Monmouthshire and South Wales Coal Owners' Association of 44.4 per cent. for large coal and 77.7 per cent. for small coal. They do not prove what profits the owners have received, for out of these prices the owners have to pay wages, royalties, the cost of stores, timber, &c., horses and horse-feeding, the upkeep of machinery and all the other expenses involved in the production of coal, and the owners state that most, if not all of these costs, apart altogether from wages, have risen at least proportionately.

The miners, on the other hand, say: "There is an increase of 7*s.* 6*d.* per ton; the advances we have received leave more than enough margin to cover the increased cost of production; the owners must therefore be making larger profits." The calculations of the Miners' Federation in support of their application for an advance of 15 per cent. on the strength of the ascertained average selling prices for the three months ended September, 1916, namely, 25*s.* 0.59*d.* per ton for large and 17*s.* 9.71*d.* for small coal, are as follow:—

If their application is granted, 66.56 per cent. of the selling price will represent wages, 21.68 per cent. stores, and 1.20 per cent. other small expenses not defined, leaving a balance of 10.56 per cent. for the owners. If the owners' application for the 10 per cent. reduction on the general wage rate is granted, wages will take 55.88 per cent. of the selling price and the owners will get 21.24 per cent. If neither application is granted, 60.15 per cent. will go in wages and the owners will retain 16.97 per cent.

By comparison with the estimated owners' balance of between 9 per cent. and 10 per cent. under agreements before the war, the Federation leaders contend that these figures show a change in the relative position of the owners and the workmen which is in favour of the owners, and that if their demand for an advance is not conceded the change will be accentuated.

That is the statistical side of the miners' case. The answer of the owners, as already suggested, is that the rise in the cost of production has kept pace with, if indeed it has not exceeded, the rise in the selling price. Not only have increases in wages added greatly to the cost per ton to the owners, but the prices of pit wood, rails, and all colliery stores have advanced, and are continually advancing. This factor, the owners contend, must be considered in conjunction with the higher selling prices in determining the relative positions of themselves and their workmen.

To this contention the miners reply with a request for a joint audit on the cost of production on the lines of the existing joint audit on the average selling price, and the owners, while adducing the cost of production as a reason for resisting the wage demand, refuse to throw open their books and disclose the secrets of their business to an auditor nominated by their employees. In these circumstances the miners hold that they are justified in the view that the profits of the owners are much higher than during the pre-war period.

CONTRACTS.—Messrs. Petters, Limited, Engineers, Yeovil, state that the Port of London Authority have accepted their tender for the supply of two 200 brake-horse-power Petter crude oil engines, to be coupled to turbine exhausters by single reduction gearing; the exhausters are used for unloading grain from ships into warehouses.

THE DONALD PORTABLE SHIP ELEVATOR-CONVEYOR.

By G. F. ZIMMER, A.M.Inst.C.E.

THE constant development of the requirements of civilisation has naturally called forth the efforts of engineers to meet those requirements, with the result that there have been evolved a vast number of labour-saving (or, as Sir J. P. Griffith, in his recent "James Forrest" lecture, wisely prefers to designate them, "labour-aiding") devices, many of them of a most interesting character. Amongst such devices those for the mechanical handling of goods—be they in bulk or otherwise—are the most important, because their judicious employment improves the balance-sheet of every industrial establishment and therefore increases the national wealth. Apart from the patriotic aspect of the case, it must be looked upon as an act of selfishness to monopolise men for work which a machine can perform as well and even better.

When reviewing labour-aiding devices one is naturally disposed by an orderly mind to classify such appliances into some kind of order; thus there are, for instance, elevators for raising material in a vertical direction, conveyors for delivering material in an horizontal or inclined direction, and devices which handle material in a combined horizontal and vertical direction, the best-known of the latter devices being the gravity bucket conveyor or elevator.

The "Donald" elevator-conveyor, built by Messrs. Rownson, Drew and Clydesdale, Limited, of 225, Upper Thames-street, London, E.C., which forms the subject of the present article, may be regarded as forming a special type. It is designed for the specific purpose of loading in and out of ships cargo of a more or less uniform nature, and in units the weight of which should, generally speaking, not exceed 2 cwt. The machines have been successfully used for handling comparatively large individual loads; in fact, such cargo as frozen mutton, bananas in crates and loose, barrels, cased and bagged stuff, cheese, drain pipes, &c., within the limits of the above weight. By changing the shape of the carriers the same machine can handle bulk goods, for instance, Brazil nuts, very satisfactorily.

Fig. 1.

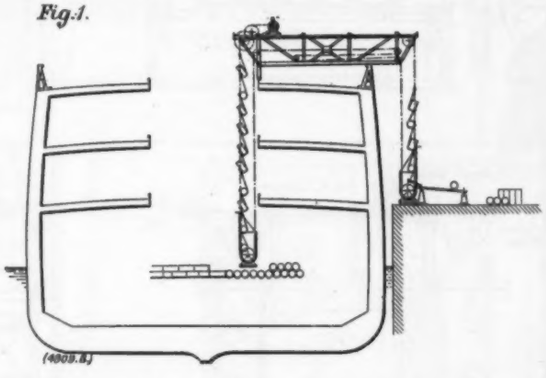


FIG. 1. DIAGRAMMATIC VIEW OF MACHINE UNLOADING A MISCELLANEOUS CARGO.

The machine proper consists of a light structural steel frame, arranged to rest with one end on the hatch coaming and with the other on the bulwark of the ship, as shown in Fig. 1; the steel framing carries a series of rollers and gearing which support and operate the two endless chains carrying the canvas slings between them in which the cargo is handled. These two chains are connected by cross traverses consisting of two tubes each, an inner one, ¾ in. diameter, which serves as a distance-piece to keep the two chains permanently in their relative position, whilst the outer tube, 1¼ in. diameter, is free on the inner one. The canvas slings are provided with a number of stout jute loops at each end which are wrapped round the outer tubes and are kept in position by a small lacing tube. The correct size of the canvas loops or slings, as they are more frequently called, is determined by the size of the packages with which the machine has to deal.

Thus, for carcases of mutton the slings would be 4 ft. wide and the two chains about 5 ft. to 5 ft. 6 in. apart, while for quarters of beef the chains would be 7 ft. apart; in both cases the slings would be 12 in. to 18 in. narrower than the dimensions between the chains, in order to leave a clearance of 6 in. to 9 in. at each side between the slings and the centre of the chain; for all other cargoes the size of the slings would be in proportion, but one might say that a 4-ft. sling will handle most cargo. These conveyors have been built for quarters of beef, which they have handled successfully, but the makers do not recommend their machines for this purpose, as they are too heavy to be handled by a ship's derrick. The speed at which the chain of slings travels is 60 ft. per minute, and the pitch of the slings varies from 2 ft. 6 in. to 3 ft. 4 in., so that a gang of six men will be employed in keeping the conveyor fully loaded.

Fig. 2, on page 504, represents such a machine with the chain stowed inside the steel framing, and both the feed boot and the discharge table lifted up to their highest position; that is the position in which the machine is slung on board or overside. The apparatus is placed in such a way that the receiving terminal plumbs the hold, and the other terminal extends over the side of the vessel, reaching either to the quay or barge alongside, wherever the cargo is to be dumped. The receiving terminal is now slowly lowered into the hold and the balance weight X (previously lowered) attached; the delivery terminal is next lowered to where the goods are to be received. A normal machine is of such dimensions as to reach to the bottom of the hold of an average vessel and likewise to reach down to the barge or dock level alongside.

To overcome any difference occasioned by the alteration in the water level or the cargo working, which alters the relative position of the ship's deck and quay level, or the depth of the hold—in other words to accommodate any portion of the conveyor chains not in use at any one time, a supplementary loop or bight is introduced into the chains. This takes the form of a pair of chain wheels H, mounted on a carriage and arranged to slide on a prescribed path, from one end of the frame to the other, by means of a rack and pinion motion controlled by a small hand winch (not shown) placed on one side of the steel framing. On the opposite side of the framing another hand winch W is placed, which adjusts the height of the hanging balance-weight X attached to the feed bight or terminal, and controls the length of the latter. The machine is generally driven by a 3-h.p. electro-motor, and the power is taken by flexible leads either from the ship's supply, or from that of an adjacent warehouse; failing electricity, small steam engines have been used successfully. The average weight of the machine as illustrated is 2 to 2¼ tons complete, so that in the majority of cases it can be safely handled by the ship's derrick.

As has already been stated, Fig. 2 shows the machine in its housed position, whilst Fig. 3 shows a cross-section through it.

In this particular example the overall length of the machine is 22 ft., the slings are 4 ft. wide, and the pitch of the slings 2 ft. 6 in. The electro-motor will be seen on top of the machine, it is geared by a silent chain-drive to a countershaft, which in turn, gears by two pinions into two main wheels—one on each side—which give motion to two sprocket wheels A. The reason why there are two such chain drives for the two sprocket wheels A is that no driving spindle must connect the upper sprocket wheels, in order to permit a clear passage for the slings with their loads. The two chain wheels A and the gear wheels which give their motion are therefore mounted on two short lengths of spindle, clear of the conveyor. The sprocket wheels B, at the other end, are similarly supported.

The chains, as they ascend on the feeding bight, when unloading a ship, pass over the pulleys A and B, down to the delivery terminal D, and ascend over the guide rollers G, H and F. As already mentioned, H forms the auxiliary bight, which takes in slack and pays out chain; from F the chain returns over E to the feeding bight again. This terminal, with its balance-weight X, is let down or pulled up by the hand winch W, over the guide pulley J; the cable supporting this weight

THE DONALD PORTABLE SHIP ELEVATOR-CONVEYOR.

CONSTRUCTED BY MESSRS. ROWNSON, DREW AND CLYDESDALE, LIMITED, LONDON.

Fig. 2. VIEW OF MACHINE STOWED.

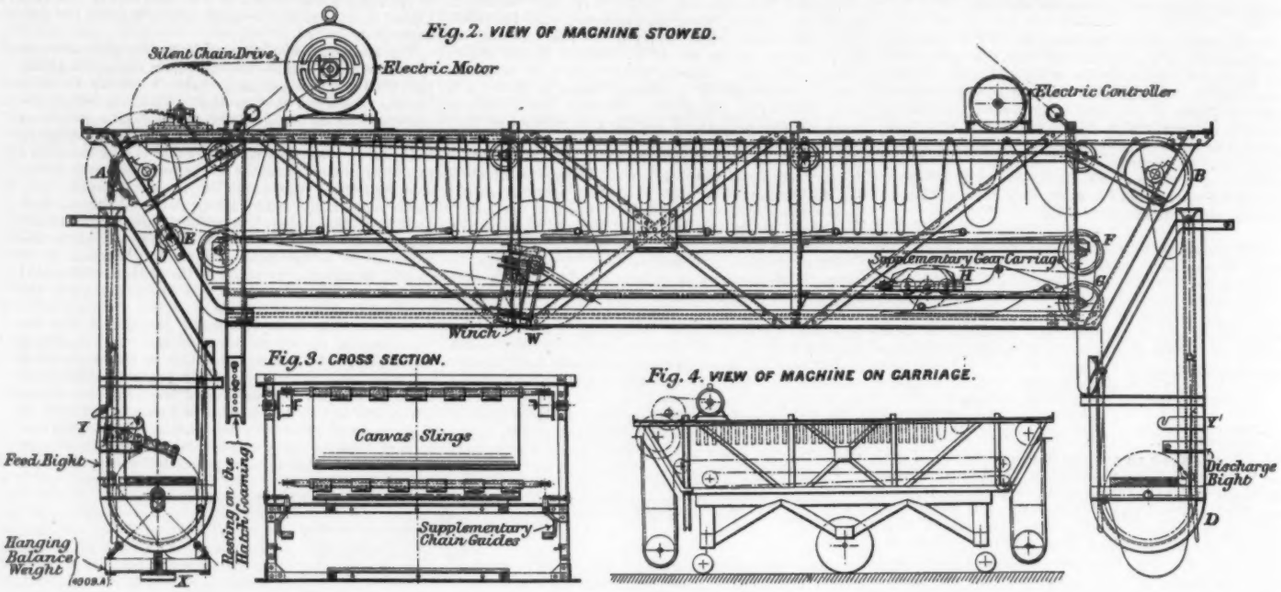


Fig. 3. CROSS SECTION.

Fig. 4. VIEW OF MACHINE ON CARRIAGE.

Fig. 5.

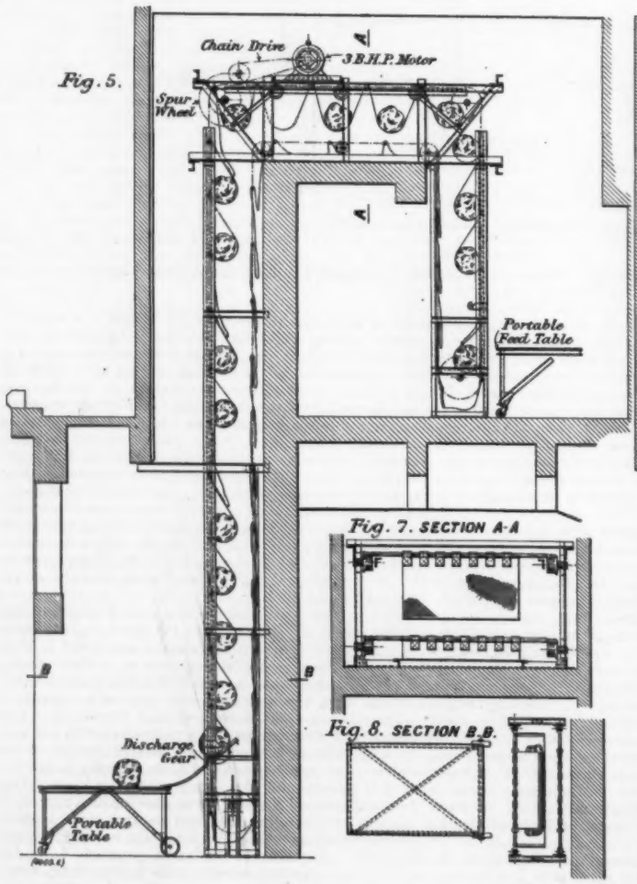


Fig. 6.

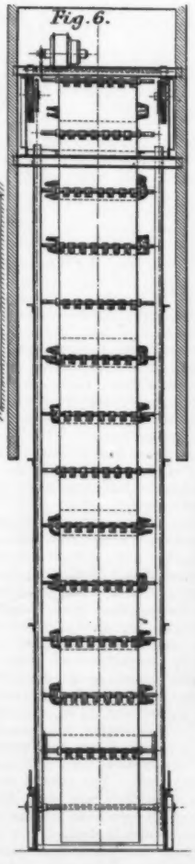


Fig. 7. SECTION A-A

Fig. 8. SECTION B.B.

FIG. 9.

divides at the lower end and is fastened to the two supporting shackles, whilst another strand of rope passes down over small rollers and up again at the other side.

The slings and chains which are seen festooned along the upper surface of the frame are only in that position when the machine is housed. The first sling, close to pulley B, is shown at its fullest extension, that is to say the pitch is 2 ft. 6 in., and the chain at the top is therefore fully stretched out; when the machine is at work all slings along the top will appear like this first one. In the succeeding double loops the longer and full line represents the sling, while the shorter dotted line of the same festoon represents the chain. The chain, when passing into the auxiliary bight, drags the slings along an iron plate, which is best seen in the cross-section; the same thing happens between E and F. In the cross-section one sling is shown as being dragged along the second iron plate.

Owing to the nature of the machine the two terminal bights cannot be rigidly connected with its upper portion, they are simply suspended by the chains and the wire cable. In the receiving and discharging positions two hooks Y and Y^1 may be seen, these are provided for a simple discharging device which can be hooked into either side of these hook attachments, depending,

THE DONALD PORTABLE SHIP ELEVATOR-CONVEYOR.

CONSTRUCTED BY MESSRS. ROWNSON, DREW AND CLYDESDALE, LIMITED, LONDON.

Fig. 10.

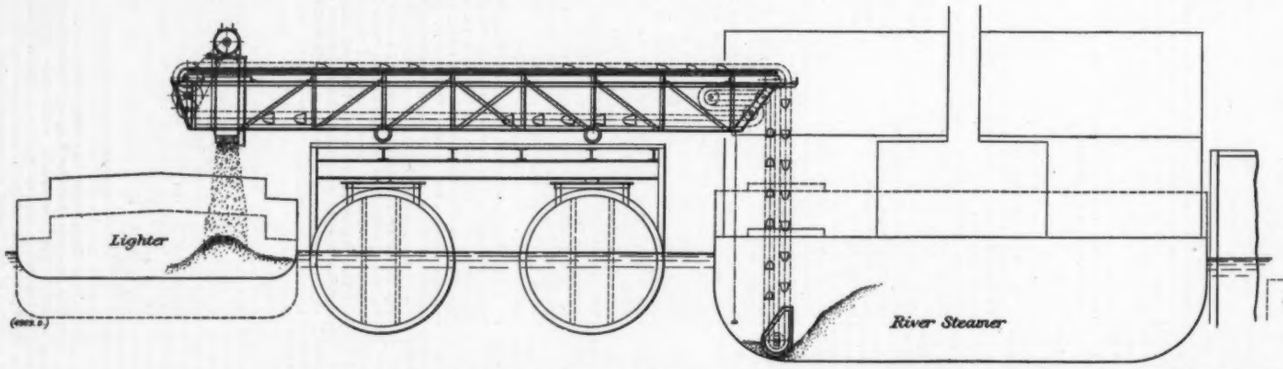
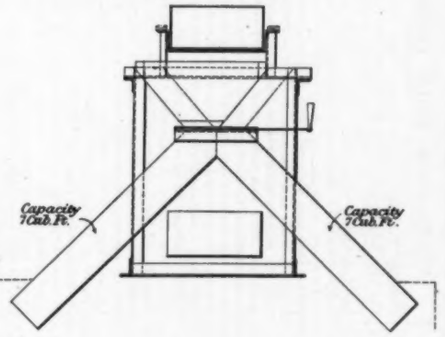


Fig. 11. CROSS SECTION



FIGS. 10 AND 11. VIEW OF ELEVATOR, MOUNTED ON PONTOON, HANDLING BRAZIL NUTS AT MANAIS HARBOUR, SOUTH AMERICA.

SIDE ELEVATION

Fig. 12.

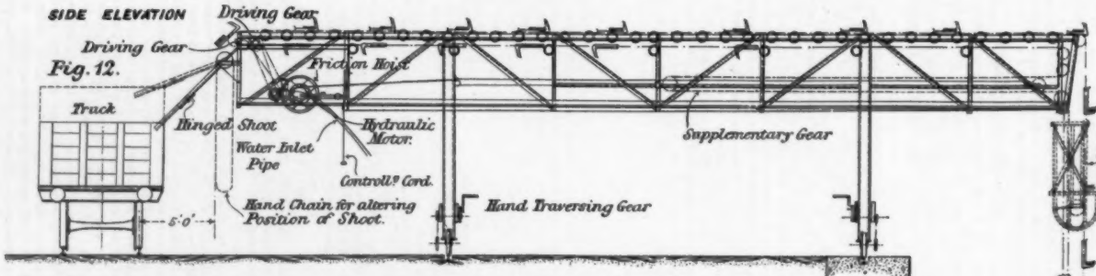


Fig. 13.

FRONT ELEVATION.

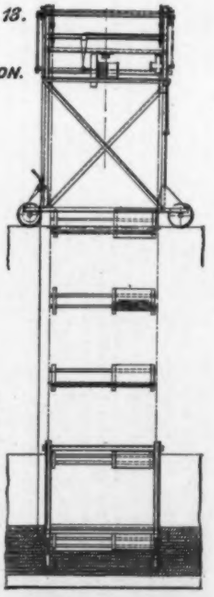


Fig. 14. ELEVATION SHOWING POSITIONS OF DISCHARGE SHOOT.

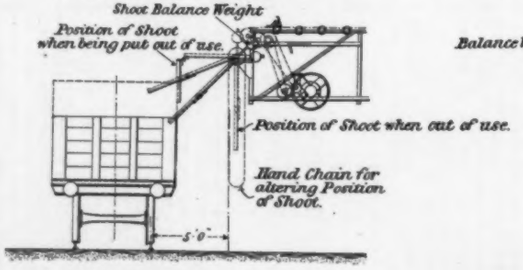
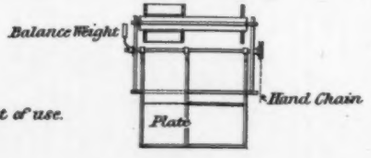

Shoot Balance Weight
Position of Shoot when being put out of use.
Position of Shoot when out of use.
Hand Chain for altering Position of Shoot.
5'0"

Fig. 15 FRONT ELEVATION OF SHOOT WHEN OUT OF USE.



FIGS. 12 TO 15. TIMBER-HANDLING INSTALLATION AT TOTTENHAM.

of course, on whether the machine is loading in or out of ship; the loading in requires no special appliance, as a man simply lifts the load into a sling which passes sufficiently slowly to enable him to do so. The delivery device for use with sacks, &c., is a plain or curved board which can be hung into the hook attachments, and which will arrest the loads on that incline, so that they can roll out on to a table or roller runway to be removed. When, however, goods in cases are handled, a short roller runway fitted with eight rollers is hooked in; this is shown at Y. The engraving Fig. 2 shows the device fitted at the feed end of the conveyor, the latter being illustrated as arranged for discharging cargo from a vessel and delivering it on to a quay. When used for discharging it works as follows:—As soon as a cross-tube supporting the sling negotiates the lever with its pawl, the table is released and tilted downward, so that the case can slide forward and the empty loop can clear the table. As soon as the load has been discharged the table tilts back again automatically into

the position in which it is shown, and the pawl catches it again.

When the unloading operation is completed, the empty conveyor is allowed to run on, the discharging bight is now wound up by lengthening the auxiliary bight, so that it will reach again the housed position, shown on the drawing, and as the feeding bight is wound up by the winch W, the chain festoons itself automatically in the framework of the machine and again assumes the position as shown in Fig. 2.

Fig. 4 shows the machine, to a small scale, on the trolley on which it is moved along the quay, and Fig. 1, on page 503, shows the apparatus in position unloading a miscellaneous cargo. This latter illustration will show, by the position of the auxiliary bight, that there is sufficient chain in reserve to let the loading terminal right down to the bottom of the ship's hold.

An advantage of the system is its large capacity with the same number of men, small wear and tear, very little noise, and considerably less damage and breakage to the goods handled than with the ordinary method of unloading by means of cranes.

Some of these appliances are employed for unloading cargoes of mutton from White Star liners at Tilbury Dock (see Fig. 9, page 504); also for automatically discharging crates of frozen rabbits, &c. Elevator-conveyors of this type are also employed by the London and North-Western Railway Company at Garston Docks, for unloading bananas from Elder and Fyffe's steamers, four of these machines and four band-conveyors being employed, and unloading over 6,000 bunches of bananas per hour.

In addition to its portable form, the device described is also built as a stationary or semi-stationary appliance on the same lines, fixed at the quayside, carried from a gantry with an extended jib, so that any vessel can be plumbed. It may also be attached to warehouses on the quay, in which case the machine is usually cantilevered from the top of a warehouse; this form is more particularly applied to loading and unloading lighters and other small craft.

A few interesting examples are illustrated in our other engravings:—Figs. 5 to 8, on page 504, represent an installation erected for the Port of London Authority for lowering carcases of frozen mutton from a cold store. The discharge gear shows clearly how the slings are emptied. Figs. 10 and 11, on page 505, show an installation for handling Brazil nuts supplied to the Manais Harbour Board, Manais, South America, the quantity handled being 25 to 30 tons per hour; here the machine is fitted with steel buckets similar to those used in ordinary elevators, and they act on the top horizontal run as push-plates. The installation is mounted on a pontoon. Similar to the last is the arrangement shown by Figs. 12 to 15, page 505, which show the device arranged for handling timber from ship to railway truck, installed at the yards of Messrs. Harris, Lebus and Co., at Tottenham, and capable of dealing with 1,000 packages per hour.

Figs. 16 to 18, on page 508, show unloading operations *ex* s.s. Malakand at Tilbury Dock from the hold to the quay. Fig 16 shows the use of portable roller runways to convey tea chests from the hold to the elevator. Fig. 17 shows the ascent of the cases, with the upper run ashore, and Fig. 18 shows the delivery of the tea chests by way of another roller runway.

Fig. 19, on page 508, shows the loading of cheeses into the hold of a steamer of the Cunard Canadian Service, and demonstrates the ease with which a man can drop the successive packages into the slings.

Personal.—Messrs. Wellman, Seaver and Head, Limited, of India House, Kingsway, London, have removed to Kings House, Kingsway, W.C., in consequence of the Government requiring the whole of India House.

Light Railways.—A new company, "Light Railways, Limited" (registered offices, 2, London Wall Buildings, London, E.C.), has been recently formed to deal with the export of all materials connected with light railways, the special object being to supplant the enormous quantities of light and portable railway materials of German origin which have reached the Colonies during recent years.

Copper Wire and Cables.—The Minister of Munitions has prohibited, from November 6, the manufacture of any copper wire or any cable containing copper, except for the purposes of any of the following contracts or orders for the time being in existence, namely:—(1) A contract or order to which there shall have been allocated by the Priority Branch of the Ministry of Munitions a reference number and priority classification within Classes "A" or "B" of Circular L. 33 as to control of output issued by the Minister of Munitions on March 31, 1916, or (2) A contract or order with and bearing the reference number and identification letters of any of the following Departments, namely: The Admiralty, the War Office, the Ministry of Munitions and the Post Office.

NOTES FROM THE UNITED STATES.

Philadelphia, November 8.

The features of the week have been inquiries for extraordinary quantities of shell steel for export, heavy orders for locomotives and extensive car orders, to say nothing of orders for very large quantities of steel material for domestic uses. The immensity of orders in sight is not disturbing the steel makers, as a rapid expansion of facilities will be provided to meet any requirements within a year or eighteen months' delivery. Shipyards and railroads are buying far into 1918 requirements, and one concern is reported as figuring on supplies for a portion of 1919. Mr. C. M. Schwab announced in Pittsburg recently that his company would shortly begin upon mill building and mill expansion, including coal and coke supplies involving the expenditure of 90,000,000 dols. Extraordinary rumours are current concerning the magnitude of expected business from the Allies. One announcement stated that 800,000 tons of shell steel would be contracted for. In the past week 150,000 tons of mill reservations were closed, of which 25,000 tons of shell steel are for France. Locomotive orders are extremely urgent. The American Locomotive Company booked orders last week for 200, including 50 for export. Car orders amounted to 900 last week. New business sent 150,000 tons of plates, shapes and bars to the market; large orders for rails are coming in, of which the Burlington system placed one for 40,000 tons with 3,000 tons structural material. Production is greatly hampered by the scarcity of labour. In the coke region alone 20,000 men are needed. A slight lull has overcome the pig-iron market because of the height to which prices went. However, inquiries are pending to-day for very large quantities from quite a number of concerns. A pipe-making concern has booked a contract for 65,000 tons of sewer and water pipe for Buenos Ayres, in competition, it is said, with makers across the water. A further upward advance in most steel prices is in sight. Furnace capacity for much of next year has been already taken.

Norwegian Enterprise in Brazil.—A company has just been formed in Christiania under the style of "Fabrica de Papel, Pernambuco" (the Pernambuco Paper Mills, Limited), for the purpose of erecting a good-sized paper factory in the vicinity of Pernambuco.

Coal in Germany.—There appears to be a desire on the part of the Rhenish-Westphalian coal syndicate to adopt a moderate rise in the prices of coal and other fuel for the new year's first term. It is argued against a rise that the increased cost of production hardly justifies such a move. Thus the report of the large Harpen coal-mining concern for the year ended June 30, 1916, states that the cost of production per ton averaged 11.81 marks and the selling price 14.86 marks. In South Germany the demand for coal continues unabated and the supplies are by no means excessive, and both Switzerland and Austria are in need of German coal and other fuel. The Saar coal-mining industry, on the whole, can only supply their buyers with a materially smaller quantity, which further enhances the demand for Ruhr coal, but certain kinds of Ruhr coal are likewise forthcoming in quite insufficient quantities.

Argentine Railway Results.—The Buenos Ayres and Pacific Railway Company, which may be regarded as the fourth great Argentine railway concern, returns its working expenses for 1915-16 at 61.16 per cent. of the receipts, as compared with 61.70 per cent. in 1914-15. The cost of maintaining the permanent way and works was 7.24 per cent., as compared with 7.54 per cent. The maintenance of locomotives cost 6.01 per cent., as compared with 7.05 per cent.; the maintenance of coaching stock 1.75 per cent., as compared with 1.68 per cent.; and the cost of maintaining live-stock trucks was 2.75 per cent., as compared with 2.24 per cent. In running expenses locomotives figured for 22.19 per cent., as compared with 21.14 per cent.; other vehicles for 0.50 per cent., as compared with 0.56 per cent.; and traffic expenses for 13.16 per cent., as compared with 13.74 per cent. The profit realised for the year ended June 30 was 1,808,033*l.*, as compared with 1,738,243*l.* in 1914-15. The expenditure on capital account in 1915-16 was 52,603*l.*, the aggregate outlay to June 30 being thus carried to 27,104,277*l.* The average length of line worked by the company in 1915-16 was 3,534 miles, as compared with 3,527 miles in 1914-15. The lines owned by the company comprised 1,430 miles, viz., double track, 202 miles, and single track, 1,228 miles, the balance of 2,104 miles was represented by leased lines. Ordinary working expenses were reduced in 1915-16 to the extent of 72,000*l.*, in round figures; but the economy thus effected was more than offset by the increased cost of fuel and of materials used in rolling-stock repairs. Firewood is being extensively used as fuel, but coal is necessary for heavy hauls and high speeds. At the close of June the company owned 720 locomotives, viz., 96 passenger engines, 319 goods engines, 209 mixed engines and 96 shunting engines. Of the 96 passenger locomotives, 44 were tender engines, 30 with four wheels coupled and 14 with six wheels coupled. Of 52 passenger tank engines, 42 were four wheels coupled, and 10 were six wheels coupled. Of the ordinary goods engines, 38 were six wheels coupled, 226 eight wheels coupled, and 6 ten wheels coupled. Of 49 goods tank engines, 31 were six wheels coupled and 18 eight wheels coupled. The 209 mixed engines owned by the company were all six wheels coupled. The 96 shunting engines were: 1 four wheels coupled and 95 six wheels coupled.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

South Yorkshire Coal Trade.—The full resources of the pits are being taxed to supply the heavy demands made for fuel of all descriptions, and particularly the manufacturing qualities. Steam hards are wanted in full numbers for munition works, blast-furnaces, railways, and export, and the full daily output is absorbed, thus preventing any accumulation of stocks at the collieries. Cobbles, nuts and slacks are all in very active demand, both for home manufacturing purposes and for shipping, bunkers, &c. The house coal market is tightening up, for in addition to the increased needs of the householders as the outcome of the spell of wintry weather, gas companies are now taking 60 per cent. of their contract accounts, as against 40 per cent. in the summer months. Cokes continue to be a difficult market, and gas coke, to which the Prices (Limitation) Act does not apply, has risen 1*s.* to 2*s.* in price. Complaints are made that the irregular railway service, particularly with regard to empty wagons, is causing serious delay at the collieries. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—With the publication of the new list of prices for nearly all metals, and the control of the sales, there is little of outstanding interest in the material market, and buying has not been on a large scale. Business in foundry pig is on the small side, forge is not much better, and the only activity is in the hematite section. Both East and West Coast continue to be required on a large scale, and the supplies are in satisfactory numbers. The Swedish position has few redeeming features. With the amalgamation of the well-known firm of Messrs. Steel, Peech and Tozer, Rotherham, and Messrs. Samuel Fox and Co., Stocksbridge, it is estimated that the joint output of open-hearth steel of these undertakings will be one of the largest in the whole country. In addition, these allied firms are adding to their furnace capacity. The Renishaw Ironworks, after being closed for nearly 18 months, are to be reopened before the termination of the present year, the plant, which includes three blast furnaces, having been entirely modernised by the new proprietors. This will lead to a substantial increase in the local production of common irons. Following upon the appearance in the market for railway steel, &c., of the North-Eastern Railway Company, other similar concerns have placed orders with Sheffield firms for rails, rolling-stock, tyres, axles and springs, and this section of the steel industry, which was neglected in the early part of the war for more urgent manufactures, is now very busy. Tramway work is also booming. Newcastle Corporation have accepted a Sheffield contract for special trackwork, and the Hull Corporation one for tyres. The Staveley Coal and Iron Company have received an order from the Sheffield Corporation for 10,000 3-in. cast-iron cable pipes. Plans have just been approved by the local authority for extension and alterations to some of the largest firms in the city, including those of Messrs. Vickers, Brown Bayley's, Edgar Allen and Co., John Brown and Co., Hadfield's, Spear and Jackson, and Doncaster and Sons. The cutlery trade, with the facilities reduced almost weekly by need of men for the Army, has a difficult task to fulfil contract accounts, but some firms have been enterprising enough to instal special machinery, and this assists them in a marked degree. The general volume of the overseas trade continues to be a source of gratification. Orders are received for railway material, forgings and castings for shipbuilding, press-work, tools, files, machetes, nuts and bolts, sheep shears and cutlery.

South Yorkshire Trade Matters.—Considerable interest was centred in the annual meeting of Messrs. Samuel Fox and Co., Limited, at Sheffield on the 17th inst. Mr. William Chesterman, the chairman, referred to the recent resignation of Mr. William H. Fox, who was chairman of the directors, and pointed out that this was solely on account of Mr. Fox's inability to attend to the duties as he would like and not to any disagreement on the question of amalgamation with Messrs. Steel, Peech and Tozer. As a matter of fact, Mr. Fox considered the union to be in the best interests of both companies. In proposing the resolution of amalgamation, the chairman observed it would add much strength to their undertaking. The scheme was based upon independent valuations, and would have a satisfactory outcome. Mr. S. G. Richardson, who seconded, observed that for over a year they had been in negotiation with Messrs. Steel, Peech and Tozer, and they were happy in being able to announce such a satisfactory outcome. He would be the very last man to prophesy in times like the present, but he thought it permissible to give expression to the hope which had been at the back of their minds all through, that the arrangements would be of great service to the company. The resolution was passed. Mr. Harry Steel was added to the directorate.

The Heroult Electric Furnace.—We read in *The Iron Age* that the Halcomb Steel Company, Syracuse, N.Y., has contracted with the United States Steel Corporation for two more 6-ton Héroult electric furnaces. The number of Héroult furnaces operated or contracted for in the United States and Canada is now 80, while on January 1, 1916, it was 43 only.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Still no change falls to be reported in connection with the pig-iron warrant market, speculative business meantime being quite a thing of the past. In every direction the stocks in public store continue to decrease.

Scotch Steel Trade.—The demand for steel of every description on Government account is a dominating force in the West of Scotland at the present time, a demand which seems to be ever increasing as the war runs its course. National interests, naturally, are of first importance, and this keeps the entire steel-making industry in a condition of the greatest possible activity. The prices prevailing are: ship plates, 14*l.* 15*s.* per ton; boiler plates, 15*l.* 15*s.* (not 14*l.* 15*s.* as stated last week); and angles, 14*l.* 15*s.*

Malleable Iron Trade.—Malleable iron continues in such exceptional demand that the mills are running at top speed, turning out the extraordinary quantities of both iron and steel required by the Home and the Allied Governments. Prices are again on the upward grade, and "Crown" bars are now quoted about 14*l.* 10*s.* per ton, with the better-named brands commanding even a higher figure.

Scotch Pig-Iron Trade.—Little or no change has taken place during the past week in connection with the local pig-iron trade, the demand for all grades being steadily on the increase. So long as the requirements of the British Government remain at the present level there is no possible chance of any export business being put through, especially in so far as hematite is concerned. There continues to be an exceptional demand for foundry and forge grades. While prices are unchanged, these show a decided tendency towards stiffening, especially for foundry and forge qualities, while quotations for hematite are practically normal, owing to the fixed rate being rigorously adhered to, and the fact that the entire output is being reserved for Government use.

Engineers and the Army.—In connection with the conference held in London last week for the purpose of defining the position of skilled labour in regard to the Army, the local secretary of the Amalgamated Society of Engineers (Mr. Sam. Bunton) has just issued a statement making quite clear the finding of the conference, which he describes as being "the most important and far-reaching ever held in the history of the A.S.E." Mr. Bunton points out the absurdity of transferring to the Army skilled mechanics whose services are much more valuable in the workshops, helping to turn out the guns, munitions, &c., required by Government. The decisions arrived at he characterises as eminently satisfactory, but at the same time he sounds the warning note that only by the hearty co-operation of all concerned can this new effort to conserve all the available labour work out successfully and the best interests of the State be served. [The decision of the conference is given in our "Industrial Notes."]

Volunteers Wanted for Munitions.—An appeal has just been sent out by the Substitution Officer at Glasgow for volunteer munition workers to take the place of men of military age who are anxious to join the Colours, but whose services cannot be dispensed with unless volunteers for the work are forthcoming. Whether men are under or over military age is of no consequence; so long as they are physically fit for the kind of work required is all that is necessary, and their patriotism may be the means of releasing a man in every way fitted for active service. The Substitution Officer says that no previous special experience is requisite, results having shown that so long as people are capable and possessed of average intelligence they very speedily acquire the desired skill, even in many of the more important branches of the work. Arrangements are being made whereby every patriotic volunteer will have choice of locality, &c.

OUR COAL ABROAD.—The exports of coal from the United Kingdom in the 10 months ended October 31 this year were 32,741,158 tons, as compared with 36,944,758 tons in the first 10 months of 1915, and 52,060,846 tons in the first 10 months of 1914. These totals were increased to 35,150,172 tons, 38,830,606 tons and 54,523,993 tons by the addition of coke and patent fuel. The exports of bunker coal to October 31 were 10,960,984 tons, as compared with 11,745,472 tons and 16,037,409 tons. It will be seen that our coal exports have fallen off very decidedly when compared with 1914, and that a moderate further decline has occurred as compared with 1915.

LARGE GERMAN ELECTRIC CENTRAL STATION.—The work at the Golpa-Iessenitz lignite deposits and the large electric central station which is to be supplied with fuel from these deposits has been somewhat retarded on account of underground water and unfavourable weather. The power station has a capacity of 180,000 kw., and the installation requires 64 boilers. The concern belongs to the Berlin Electricity Works. Whilst the work is going on energy has been generated mostly by means of fuel from other sources. During the last year efforts have particularly been aimed at supplying as soon as possible the current necessary for the Bavarian Nitrogen Company and the Electro-Saltpetre Company. The contract with the latter concern, which is located in the vicinity of the power station, is for 240,000,000 kw.h. annually. The station began work in December, 1915, with a continuous load of 15,000 kw., which by the end of the financial year, June 30, had risen to 25,000 kw. The current year also will be marked by continued construction and a gradual increase of the energy generated.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is rather more active, and prices are very firmly maintained. Removal of the prohibition of sales of foundry iron delivered to Scotland beyond this month has brought in considerable orders from that quarter for supply to the end of the year. Consumers nearer home are fairly well bought, but some English foundries are inquiring for iron delivered over the first six months of 1917. Makers, however, will not commit themselves beyond the first quarter of the year and even over that period they are not disposed fully to satisfy demands as they are apprehensive of the issue of further regulations concerning the use of various qualities which may render void contracts made for No. 3. Consumers are receiving adequate supplies under present contracts. No. 3 Cleveland pig, No. 4 foundry and No. 4 forge all stand at 87*s.* 6*d.* for home consumption, and No. 1 is 91*s.* 6*d.*; whilst for shipment to our Allies No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutral countries No. 3 is put at 105*s.* and No. 1 at 110*s.* Licences are granted for shipment of small occasional lots under exceptional circumstances, to Scandinavia.

Hematite Iron.—In East Coast hematite iron the position is, if anything, slightly easier. Home users are well placed, and fair quantities are available for delivery to the Allies, but licenses for shipment are issued only strictly in accordance with actual needs. Negotiations for substantial contracts over periods next year are proceeding. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Output of Pig-Iron.—Definite information as to when certain furnaces will be re-started is not obtainable, but several both on hematite and Cleveland are expected to be put into operation very shortly. One idle furnace will probably be blown in on Cleveland iron almost immediately.

Stocks and Shipments of Pig-Iron.—The stock of Cleveland pig-iron in the public warrant stores alters very little. The quantity held now stands at 4,173 tons, consisting of 4,137 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard. Since the beginning of the month the stock has been reduced by the withdrawal of 261 tons of No. 3. Recent heavy weather has interfered with shipments. Official returns give the clearances at Middlesbrough so far this month at 16,510 tons, as compared with 28,733 tons to the same date last month, and 20,954 tons for the corresponding part of November last year.

Coke.—Coke continues in heavy demand for local consumption, and values of the qualities needed are well maintained notwithstanding the much more than ample supply. Medium blast furnace kinds stand at 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is still quoted for qualities low in phosphorus.

Foreign Ore.—Bad weather has checked delivery of foreign ore. Imports to the Tees so far this month amount to 90,623 tons.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel keep very busy on Government work. There are numerous ordinary commercial inquiries in the market, but they attract little attention. The only ordinary business passing of any consequence is for mercantile shipbuilding material, the output of which is very large and increasing. Quotations, all round, are strong. For home use common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.* The following rates are named for shipment:—Common iron bars, 15*l.*; steel sheets (singles), 20*l.*; steel sheets (doubles), 22*l.*; and heavy steel rails, 11*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam coal trade has ruled quiet. Tonnage arrivals have still been inadequate, and colliery owners have been freely offering concessions to buyers for immediate shipment in order to clear trucks quickly and obviate pit stoppages. Forward quotations have, however, been maintained, it being considered that the present adverse tonnage position is only temporary. House coal, patent fuel and coke have remained without change. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 29*s.* to 30*s.*; Monmouthshire Black Veins, 29*s.* to 30*s.*; ordinary Western Valleys, 28*s.* to 29*s.*; Eastern Valleys, 28*s.* to 29*s.*; best bunker smalls, 18*s.* to 19*s.*; and cargo smalls, 15*s.* to 18*s.* per ton. In bituminous coal best households have realised 25*s.* 6*d.* to 26*s.* 6*d.* at the pits; No. 3 Rhondda large, 29*s.* to 30*s.*; smalls, 25*s.* to 26*s.*; No. 2 Rhondda large, 26*s.* to 27*s.*; and No. 2 smalls, 18*s.* to 19*s.* per ton. The latest quotation for patent fuel has been 40*s.* to 42*s.* 6*d.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.* per ton.

Western Trade Matters.—The Aberdare Gas Company is considering the raising of further capital.—Mr. P. H. Jones (deputy-chairman), presided at the half-yearly meeting of the Sharpness New Docks and Gloucester and Birmingham Navigation Company. Mr. Jones said the undertaking had had to deal with a lean year, in consequence of the adverse influences of the war. In 1912-13 the movement of goods over the company's undertaking was 572,522 tons; in 1915-16 the corresponding movement declined to 280,031 tons; the company's business and revenue had thus been decreased by one-half. During the past 12 months, however, the company had paid a full year's interest upon its debentures and debenture stock, and 3,986*l.* had been carried to the works and contingency reserve. The Government had commandeered about 13 acres of the company's property. A start had been made with a great shipbuilding industry at Chepstow, there had been a large purchase of land for manufacturing purposes at Avonmouth, and the next place which would be considered was probably Sharpness.—The annual meeting of the Court of the University of Bristol was held on Friday at the university buildings, Dr. G. A. Wills, pro-chancellor, presiding.—Dr. Wills stated that the Faculty of Engineering maintained by the Society of Merchant Venturers had been able to render a great service in training workers for munition factories; it had also been lately training members of the Royal Flying Corps. The university had at present very few persons available to carry on researches, but it had not been altogether wanting in that respect. A scheme for the training of engineers initiated by Professor Wertheimer in the Faculty of Engineering had received the appreciation of a number of firms of eminence and importance scattered over a large part of England and Scotland. The Treasury had made a special grant to universities to carry them over the present time of difficulty; Bristol's share in this grant was 875*l.* per annum; and that sum had been received for 1914 and 1915.—Speaking on Friday at a meeting of the Cardiff Business Club, Lord Rhondda laid down the principle that no man should be allowed to make a profit out of the war and that the Government should have taken all the extra profits of shipowners and coalowners. He suggested that the Government should take over the Admiralty collieries and make what profit they liked, provided they guaranteed the owners a fair and reasonable profit on their investment. He was told, however, by a man who knew less about collieries than he did, that this was impracticable. Selfishness was at all times the stimulus to progress. He thought the bargain between the Government and employers and workmen made before the war regarding the restrictions imposed should be fully carried out and that trades unionists should be in exactly the same position as they were before the war. In the interest both of employers and workmen everything should be done to secure the greatest joint production. That was the way to meet competition.—An appeal of Watts, Watts and Co., of Cardiff, New York and London, against the Union Navigation Company of Austria, which is now pending in the Supreme Court of the United States, will not be reached for some months unless a motion to advance it is made by counsel and is granted by the Court. The case arose through the agents of Watts, Watts and Co., in connection with a vessel of the Union Navigation Company of Austria in Northern Africa shortly before the outbreak of the present great European war. When the bills of exchange by which payment for the vessel was made arrived in London, war had been declared, a moratorium had been granted, and the bills were not paid. Upon the arrival in New York of a vessel owned by the Union Navigation Company of Austria the New York representatives of Watts, Watts and Co. attempted to file a libel upon the ship to enforce payment. The Federal Court held that both parties were foreign corporations, and as by the laws of their own countries no payments could be made on contracts until the close of the war there was no special reason why the Courts of the United States should take jurisdiction over the case, and it was accordingly dismissed. Upon this, Watts, Watts and Co. filed an appeal to the Circuit Court, which upheld the decision of the District Court. Watts, Watts & Co. next appealed to the Supreme Court of the United States.

DECLINE OF THE GAS ENGINE.—Dealing with this subject, the journal *Power*, New York, says that probably the greatest factor in the decline of the gas engine has been the rapid development of the steam turbine in all sizes and types. Managers of plants are attracted by the low first cost, the increasingly high steam economy, the uniform reliability and the simplicity of operation of the modern steam turbine.

THE WORLD'S OUTPUT OF PETROLEUM.—The production of petroleum throughout the world, according to *Commercial America*, was, in 1860, 508,578 barrels of 42 gallons each, of which 500,000 fell to the United States and 8,542 to Roumania. In 1915, the total output was 426,892,673 barrels, of which 281,104,104 came from the United States, 68,548,062 from Russia, 32,910,508 from Mexico, 12,386,808 from the Dutch East Indies, and 12,029,913 from Roumania.

AMERICAN LOCOMOTIVE BUILDING.—The total number of locomotives ordered in the United States in the first half of this year was 2,124, while orders for 878 more were booked in the four months ending October 31. The year's aggregate was thus carried to 3,002 engines. The number of locomotives for which contracts were let in October was 386; of these 173 were ordered by foreign buyers. Orders for 127 engines have been recently secured by the American Locomotive Company; the largest order (77 engines) was given out by the Chicago & North-Western Railroad Company.

THE DONALD PORTABLE SHIP ELEVATOR-CONVEYOR.

CONSTRUCTED BY MESSRS. ROWNSON, DREW AND CLYDESDALE, LIMITED, LONDON.

(*For Description, see Page* 503.)

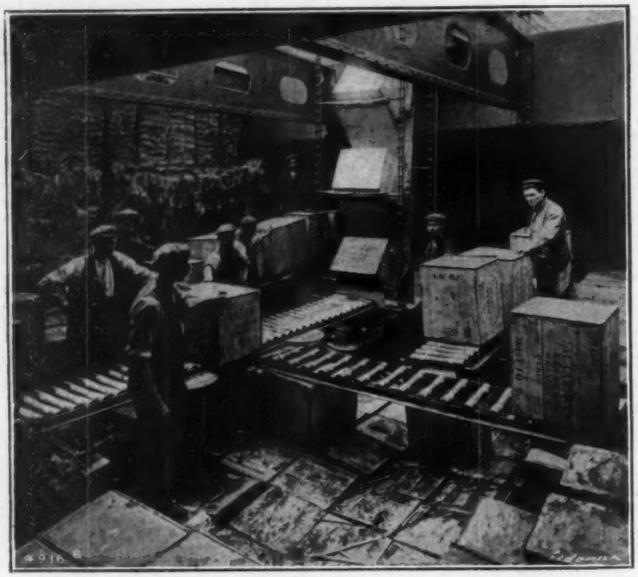


FIG. 16.

FIG. 19.

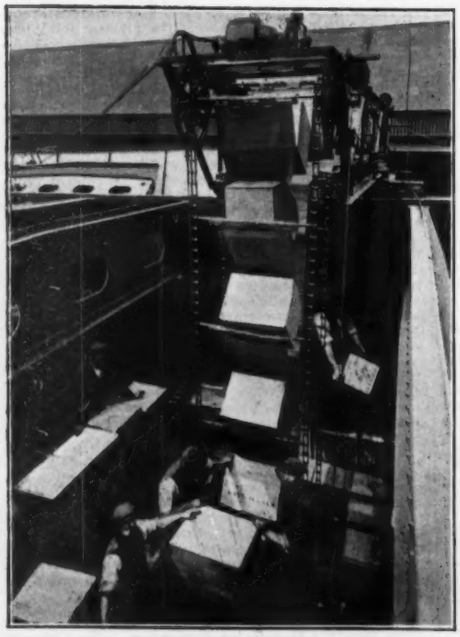


FIG. 17.

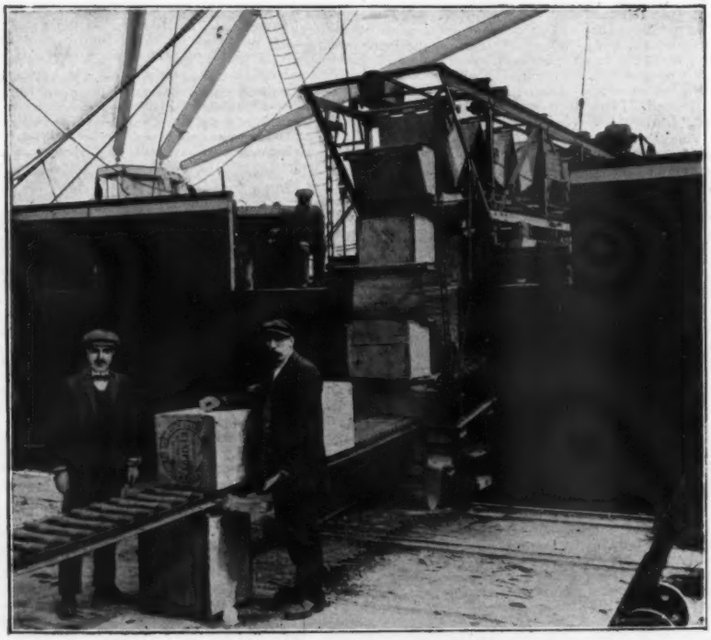


FIG. 18.

GOLD, SILVER, COPPER, LEAD AND ZINC IN THE EASTERN UNITED STATES, 1915.—The term Eastern States comprises, in the publications on "Mineral Resources of the United States," all the Eastern States, including Alabama and the eastern part of Tennessee. According to the compilation of Mr. James M. Hill, the production of ores was 2,215,538 short tons in 1915, against 1,842,890 tons in 1914, but the value of the ores of 1915, 29,968,372 dols., was by 158 per cent. higher than in 1914. The small increase in production mainly concerned zinc mines, the huge increase in value was due to the war prices, though silver prices went down. The gold production aggregated 10,848 fine ounces, the silver production 102,543 fine ounces; the zinc production was 312,498,575 lb., an increase of 142,781,621 lb. over the output of 1914.

NEW SOURCES OF OIL.—German chemical journals have had a good deal to say of late about the extraction of oils from various stone fruits, seeds, chestnuts, &c. Quite a good oil was obtained from the small seeds of the popular lime or linden trees (*Tilia tomentosa* and *parvifolia*); the War Committee on Oils found, however, that the seeds were too often dried up and unsuitable, and rarely contained the 2½ per cent. of oil which was extracted in some cases. The common horse-chestnuts, on the other hand, so far utilised only for feeding cattle, seem to yield a good table oil. As regards the kernels of fruit trees, plums, cherries, peaches, &c., several processes have been proposed and are under trial. K. Alpers, of Tübingen, crushes the stones in special machines, which leave the kernels fairly intact and drop the pulp into aqueous salt solutions (magnesium or calcium chloride); the stones having a density of about 1.18, the kernel pulp of 1.05, and the salt solutions of 1.15 (about), kernel and stone are separated by flotation and the oil is afterwards extracted. There is a prejudice against chemically-extracted oils for culinary purposes, but as a matter of fact such oils have long been used in the household. The oils from plums, &c., contain, however, some prussic acid; that can be removed by passing steam through the oil, the steam carrying the poisonous acid away; the residual taste and smell of bitter almonds is not unpleasant to many palates. The idea of using salt solutions for the separation of shell and kernel is not novel. J. Merz, of Brünn, Austria, extracts the finely-crushed pulp of stone and kernel directly with hot solvents, so that the prussic acid escapes during extraction.

PASSENGER LOCOMOTIVE (4-4-0) OR

CONSTRUCTED FROM THE DESIGNS OF MR. PICK

(For Descripti… see Pa…

Fig. 1.

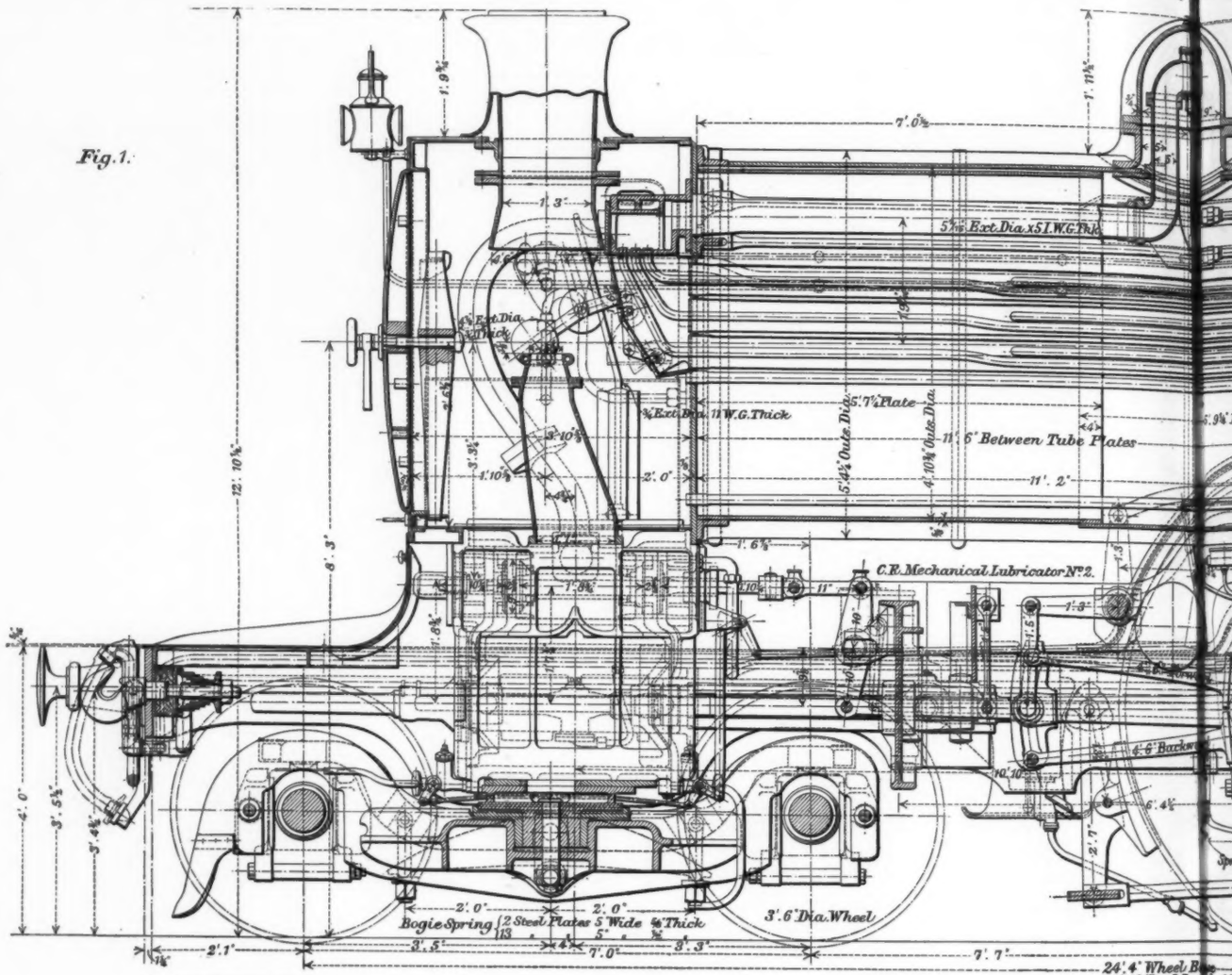
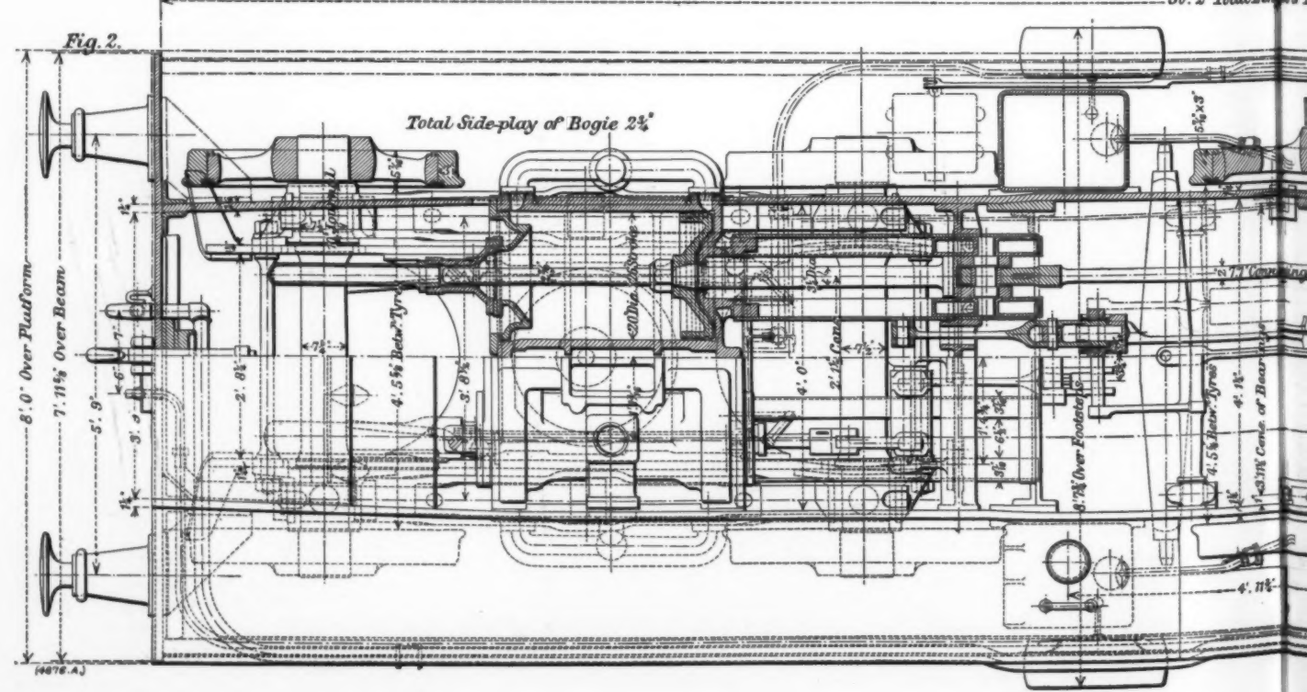


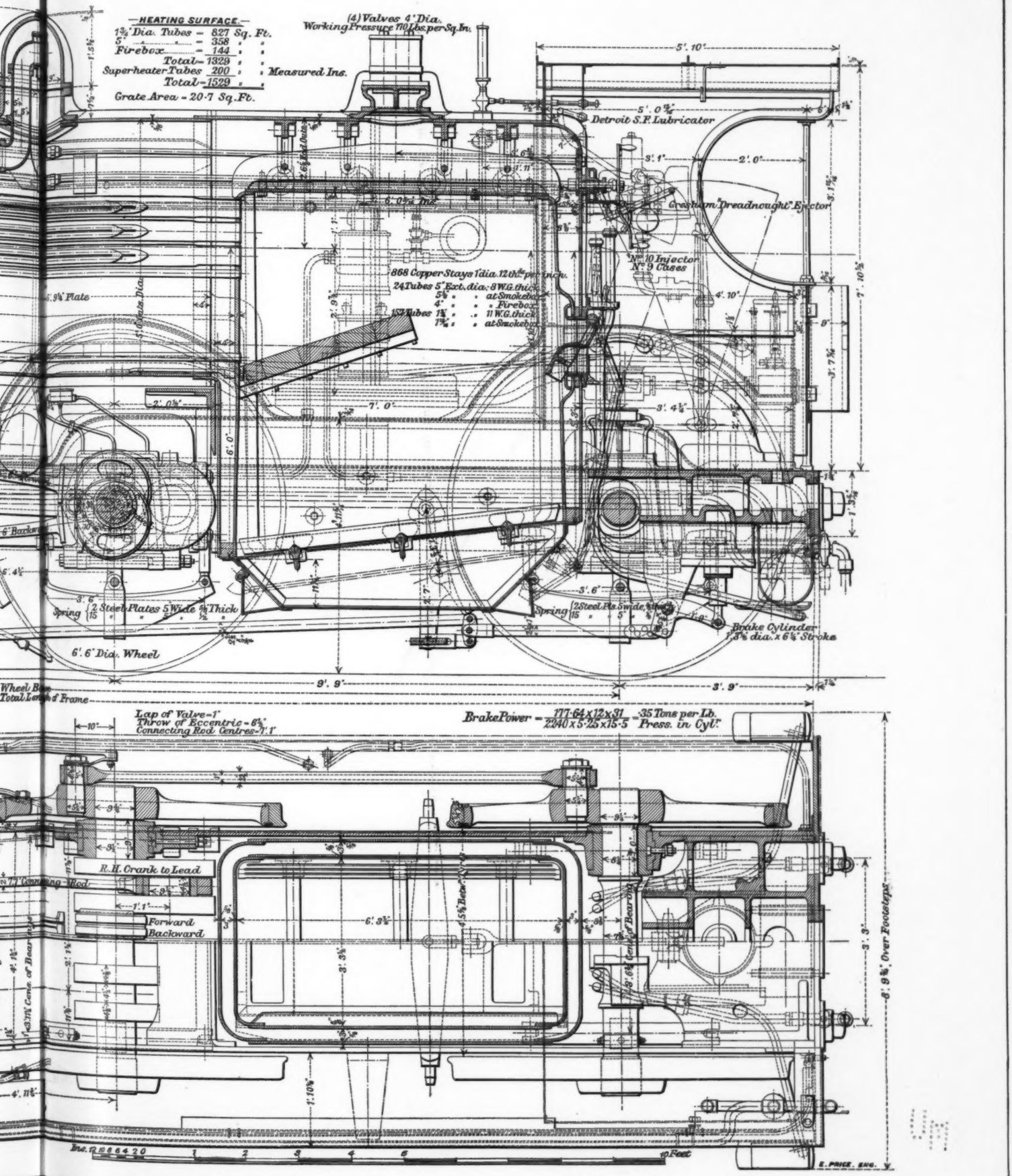
Fig. 2.



OR THE CALEDONIAN RAILWAY.

OF MR. PICKERSGILL, LOCOMOTIVE SUPERINTENDENT.

r Descrip... see Page 499.)


HEATING SURFACE
1⅜" Dia. Tubes = 827 Sq. Ft.
5" " " = 358 " "
Firebox = 144 " "
Total = 1329 " "
Superheater Tubes 200 " " Measured Ins.
Total = 1529 " "
Grate Area = 20·7 Sq. Ft.
(4) Valves 4" Dia.
Working Pressure 170 lbs. per Sq. In.
5'. 10"
5'. 0⅝"
Detroit S.F. Lubricator
3'. 1"
2'. 0"
6'. 0½" max.
Gresham "Dreadnought" Ejector
No. 10 Injector
No. 9 Cases
868 Copper Stays 1 dia. 12 th. per sq. in.
24 Tubes 5" Ext. dia. 8 W.G. thick
5⅛" " at Smokebox
4" " " Firebox
152 Tubes 1¾" " 11 W.G. thick
1¾" " at Smokebox
4'. 10"
7'. 0"
3'. 4½"
3'. 6"
Spring 2 Steel Plates 5" Wide ½" Thick
15 " " 5" "
3'. 6"
Brake Cylinder
1'. 3⅝" dia. x 6¼" Stroke
6'. 6" Dia. Wheel
3'. 9"
3'. 9"
Lap of Valve = 1"
Throw of Eccentric = 6⅜"
Connecting Rod Centres = 7'. 1"
Brake Power = 177·64 x 12 x 31 / 2240 x 5·25 x 15·5 = ·35 Tons per Lb. Press. in Cyl.
R.H. Crank to Lead
Forward
Backward
6'. 3¾"
3'. 3"
3'. 9¾" Over Footsteps
Scale. Feet
E. PRICE, Engr.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaugnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£1	15	6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—

Thin paper copies	£1	11	6 ($7.65)
Thick "	£1	16	0 ($8.75)

For all other places abroad—

Thin paper copies	£1	16	0
Thick "	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8506 GERRARD.

CONTENTS.

	PAGE
The Torsion of Solid and Hollow Prisms and Cylinders (*Illus.*)	497
The Classification of Railway Failures	498
Passenger Locomotive (4-4-0) for the Caledonian Railway (*Illus.*)	499
Punching Machine with Electrically Controlled Gag (*Illus.*)	501
Industrial Notes	502
The Donald Portable Ship Elevator - Conveyor (*Illus.*)	503
Notes from the United States	506
Notes from South Yorkshire	506
Notes from the North	507
Notes from Cleveland and the Northern Counties	507
Notes from the South-West	507
High-Speed Steel Alloys	509
Shipyard Efficiency	510
The Pyrogenesis of Hydrocarbons	510
Notes	511
Literature	512
Books Received	514
"Spark Ignition"	515
Trials on a Diesel Engine	515
Electron, Quanta and Relativity Theories (*Illus.*)	515
Prussian Crown Coal Mines	515
Keadby Bridge	516
The Physical Society of London	516
The Parallel Operation of Electric Power Stations (*Illus.*)	517
Catalogues	519
ENGINEERING Patent Record (*Illus.*)	520

With a Two-Page Plate of a PASSENGER LOCOMOTIVE 4-4-0) FOR THE CALEDONIAN RAILWAY.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday, November 27, at 5 p.m. Howard Lecture.—"Coal and its Economic Utilisation," by Professor John S. S. Brame, Royal Naval College, Greenwich. (Lecture I.) Wednesday, November 29, at 4.30 p.m. "The Internal Combustion Engine," by Dr. Dugald Clerk, D.Sc., F.R.S., Chairman of the Council of the Society. The Hon. Sir Charles Algernon Parsons, K.C.B., M.A., D.Sc., F.R.S., will preside.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 29, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Mr. T. L. Norfolk, Assoc.M.Inst.C.E., entitled "Notes on the Design and Construction of Modern Dock Gates."

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 24, 1916.

HIGH-SPEED STEEL ALLOYS.

HIGH-SPEED steel is one of the most important factors—if it be not the most important factor—in the very complex problem of the supply of munitions. Its use means a very great increase of output, and a corresponding decrease of labour costs. But at the commencement of the war we were face to face with the prospect of a famine in high-speed steel, at least of that of the best quality. As everyone knows, the most important element in this alloy steel is tungsten, which is used in the proportion of 18 to 20 per cent., so that large quantities were needed in peace time to supply our own wants, and also the requirements of our great export trade. Under war conditions the demand has enlarged enormously, both at home and among our Allies, and consequently we are using more tungsten. At the time war was declared no tungsten powder was being produced in this country. The ore was found in many parts of the Empire, and also in other lands, but most of it went to Germany and was manufactured in a single town. Once the Germans had got hold of the trade it was felt to be hopeless to try and start the manufacture here; "spoiling for a fight" is not a psychological phenomenon in British manufacturers. Hence it came that in August, 1914, Sheffield steel makers found themselves faced with the prospect of an enormous demand for high-speed steel, towards which they had only three months' supply of tungsten powder, and not a single works in this country to supply more.

Very early in the war the question of the supply of tungsten came before the Government, which, in this respect, was represented by Lord Moulton and Sir Boverton Redwood. They came into communication with Mr. A. J. Hobson, of Messrs. William Jessop & Sons, Limited, and with Mr. Arthur Balfour, of Messrs. Arthur Balfour and Co., Limited, and through these gentlemen with many of the steel makers in Sheffield and elsewhere. By tact and diplomacy, aided by the shadow of coming necessity, some thirty firms, whose combined output of high-speed steel prior to the war was from 70 to 80 per cent. of the total output in this country, became shareholders in a company formed to put up a works for the production of tungsten powder, and this works is now turning out three tons per day of excellent quality. The Government has given them great assistance in procuring ore. By the loyal co-operation of the Colonies and Dominions they have fixed the price of ore at a figure which is very moderate as compared with that ruling in neutral countries, but yet is sufficiently high to encourage the miners to turn out all they can from existing sources and to enter into prospecting operations in likely districts. There is every prospect that the supply of ore will be more than maintained, but further supplies will be welcomed as they arrive.

A great crisis in our metallurgical industry has been faced and passed by the combined action of the makers of high-speed steel, and a new manufacture has been established in this country. There was never any scientific reason why it should not have taken root here before. The reduction of tungsten from its ores is a matter perfectly understood by chemists, and although the practical exploitation of the process presents difficulties, like all chemical manufactures on a large scale, yet the fact that these have been entirely overcome by the new company in a comparatively short space of time shows that they never were a bar to the foundation of a British enterprise in tungsten. The difficulty arose from the inferior commercial power of British individualism when opposed to German collectivism. The Germans early recognised the coming value of tungsten and set themselves to secure the trade for themselves. They secured considerable control of the ore market, and were early in the field with the metal itself. "What Prussia takes Prussia keeps" has a meaning beyond warfare and diplomacy, and just as no single nation would have dreamed of going to war with the Triple Alliance, so no manufacturer cared to break himself against the combined resistance of tariffs, banks, railroads, shipping and the metallurgical interests of Germany, all acting towards a single end. What individual effort was powerless to do, however, war has effected, and we have now a fairly satisfactory supply of tungsten powder from more than one home source. It must never be forgotten that the works have been put down very hurriedly, at a time when material is scarce and prices are inflated, and that their first object has been to turn out material in quantity far more than to turn it out cheaply. The object of the promoters has been achieved, but in so doing a very considerable capital has been sunk, and it is impossible to ignore the fact that peace will work a great change in this industry, as in others. The prudent man—there are plenty of them in Sheffield—would write down his capital out of war profits, so that he might face the perils of peace with a light cargo. But this is nearly impossible with the war profits tax of 60 or 65 per cent., followed by an income tax of 25 per cent., collected by a Treasury which is absolutely relentless in its search for sources of revenue. If moderately reasonable dividends are to be distributed, very little writing-off is feasible at the present stage of the new industry, and it may easily find itself again faced by German competition under conditions which will be difficult to meet. When the Government can spare time and thought for less urgent matters than winning the war it will find plenty of such problems awaiting consideration. Hitherto we have always taken what appeared to be the easiest road to money-making at the moment, and have given little heed to security. In the future we must put security first—not only national security, but security of our trade—even if we have to pay something to attain it. We are paying five millions a day at present, and if we fall back into our old commercial position most of this will be wasted.

Tungsten is used in two forms—ferro-tungsten and tungsten powder. The former is fairly simple to produce from the ore, but it suffers from the disadvantage that it contains most of the other metals and elements that are present in the ore. Tin can be eliminated by magnetic separation, but the iron, manganese, arsenic, and probably the sulphur remain, and, some of them, at any rate, are most undesirable in the steel. The ground ore is mixed with powdered aluminium in a crucible, and the reaction is started by a "wick," and then goes on vigorously enough, as the mixture is practically an imperfect "thermit." The result is ferro-tungsten, which before the war was made on a considerable scale in France, and to some extent in this country. Tungsten powder is very nearly the pure element. The German product was of about 97½ per cent. purity, while that now made in this country averages over 98½ per cent., and a great deal of it is over 99 per cent. As it constitutes some 20 per cent. of the final tool steel it needs no argument to show how important it is that it shall not contain other elements. Wolfram, the ore of tungsten, occurs with tin, but as it is magnetic the separation is not difficult. Tungsten is also found in the form of Scheelite, which consists of lime and tungstic acid, with impurities. At present it is wolfram that is being chiefly used in

this country, and is being imported here from many places. The new company—High Speed Steel Alloys, Ltd., of Widnes—has secured two mines in Burmah, and has sent out a staff of geologists, chemists and mining engineers to represent it there. These will see to the crushing of the ore, the separation of the gangue and of the tin, as far as possible, and will then ship it to this country in barrels. Ores from other sources often contain some tin, and are sent through a magnetic separator. Tungstic acid is magnetic, and is therefore easily separated from tin oxide.

To facilitate the chemical reactions the ore is very finely ground. The first operation takes place at dull red temperature, and it is important to secure intimate contact between the reagents, first by grinding, and secondly by stirring or rabbling. The ore is mixed with soda in determined proportions and is fed into a reverberatory furnace, where it remains until it is completely converted into tungstate of soda (Na_2WO_4). This comes out of the furnace, together with the iron, manganese and other bodies, in the form of clinker, which has to be broken up and ground before it is boiled with water. The tungstate of soda is soluble, and is separated from the other insoluble constituents by means of filter presses. It is then concentrated by evaporation, mixed with hydrochloric acid and boiled by means of steam, the result being yellow oxide of tungsten (WO_3). It is about of the consistency of treacle, and is partly dried in a centrifuge, after which it is completely dried by heat and finely ground. It is next mixed with the proper percentage of ground anthracite, and heated in crucibles for 24 hours, followed by 12 hours' cooling in the furnace. This effects the reduction to the metallic state, leaving the crucible filled with a friable mass. The impurities, which have escaped separation in the filter press and dissolution in the acid, congregate at the top, and can be removed by hand picking, their presence being revealed by their colour. The pure metal is again ground, and is washed in successive portions of hot water to remove any ash remaining from the anthracite, or any soluble soda salt which has escaped the previous treatment. A final drying renders the metal ready for packing and for dispatch to the works.

The new company has attained its designed output of three tons per day, but it has not yet fulfilled all its ambitions. It aims first at rendering its process as nearly automatic as possible, at using gas firing in place of coke firing, and of reducing hand labour still more. It will then turn to the more difficult problem of pure and impure ores, which, of course, involve more complicated chemical reactions. When this has been done our sources of supply will be widened, and possibly the cost of ore will be reduced, as the impure ores may be more easy to mine. What part tungsten may play in the future of engineering it is impossible to say. At war prices its use is limited to tools, and even at the old price of some two shillings per pound it had a very restricted outlook. If the cost can be reduced by invention, or by the use of cheaper material, then we may look forward to new uses being found for it. The fact that a complete works has been created in a few months, and that its product is more than satisfying the purchasers, is evidence that it is not for lack of engineering and chemical knowledge that we have so far fallen behind the Germans in some fields. If our commercial and political machinery were as efficient as that turned out of our engineering shops there would be no cause for apprehension as to what will happen in our future commercial struggles.

SHIPYARD EFFICIENCY.

The rapid and economical building of merchant ships to replace those lost and destroyed during the period of the war is a matter of such vital importance to the nation that it is the duty of shipbuilders and engineers to see that all plant under their charge is brought to the highest state of efficiency, and that all possible plans are laid to cope with the demands for new tonnage which will shortly have to be met. Alterations to and extensions of existing shops, renewal of machinery and other improvements, which may have been in contemplation and which have been put aside owing to the pressure of war work, must be carried through at the earliest possible moment. Those firms who have hitherto depended solely or largely on the building of war vessels must be prepared to face the possibility of a temporary stoppage of the building of such vessels, and must be ready to undertake instead the construction, under the keenest competitive conditions, of merchant vessels. This will almost certainly involve the employment of more speedy and economical methods of working, and may also necessitate the introduction of new machinery. It is doubtful if any very great accession to the number of skilled workers available after the war can be looked for, as while a great many of the very best men joined the army in the early days of the war—to the serious disadvantage of the industry of the country—it is unfortunately only too likely that very many of these volunteers will not return, or will return maimed; also, as skilled workers are not now recruited for the army, the return of these men after the war will not appreciably affect the situation as regards skilled tradesmen. It is, therefore, the more imperative that advantage be taken of every available means of enlarging and cheapening the output by increasing the efficiency of plant and by the improvement of means and methods.

Leaving out of count the question of workmen's wages, there are several points which are worthy of some consideration. Facilities for the rapid handling and transporting of plates and angles are a first essential. Raw material on delivery should be laid out for purposes of checking and distribution to the workmen in such a position that it is delivered to the plater's shed on the side remote from the building berths, in order to avoid the waste of time which occurs when raw material entering and finished material leaving the sheds meet on the same traffic lines. Too little attention is usually paid to the state of the ground between the sheds and the building berths, and as a consequence the ground becomes a sea of mud and water in bad weather. Where narrow-gauge railway lines are laid for the transport of material on bogies, this defect is perhaps not so serious, but where no such transport arrangements are in use the moving of heavy items becomes a matter of difficulty and still further cuts up the ground. Where mechanically-propelled vehicles are in use the provision of suitable roadways becomes a necessity. Apart altogether from these considerations, the provision of good dry roadways is bound to have an influence on the health and comfort, and therefore on the output, of the workers by enabling them to keep their feet dry.

The building of vessels under cover is of immense value in expediting construction during the bad weather of the winter months, and a further great advantage is that during very bad weather the men employed on vessels building in the open can be temporarily transferred to the vessel under cover, instead of being sent home. Wherever possible at least one berth should be covered in, have one side enclosed, and should be served by one or more overhead travelling cranes. The provision of a suitably equipped covered berth involves a considerable capital outlay, but this is counterbalanced by the resulting continuity of work and consequent ability to keep to promised dates of delivery. Ships built under cover can and should be launched in a very advanced state as regards completion of decks, fittings on decks and interior work generally, the completion of deck work enabling the vessel to be kept dry after launch, and consequently allowing the work of fitting out to proceed rapidly. In all cases it is of the greatest advantage to complete all work possible before launch, because it is undoubtedly a fact that men work more steadily on a vessel on the stocks than they do on the same vessel after launch; also it is easier and cheaper to stage the outer parts of a vessel while she is on the stocks. The extra time which a vessel is kept on the stocks can be very profitably used in preparing all the material possible in readiness for the laying down of the succeeding vessel on the same berth. In this way a full start can be made on the newly laid down vessel at a very early stage and work kept going continuously, instead of the keel being rushed down and the frames erected in small lots as they are prepared and delivered from the shops, as is not infrequently done.

A shortage of local supervision by under-foremen is a common source of loss in efficiency and economy, for the time lost by the stoppage of men owing to some unforeseen difficulty cropping upon their job, or through "slacking," would cover the wages of an under-foreman many times over. Systems of payment—whether piece work and its variations or a time rate—will have to be revised and an effort made to arrive at a workable basis before the need for its immediate application arises, for it is obvious that the system, or rather lack of system, which obtains under the present abnormal conditions cannot continue after the war, and a return to pre-war conditions is equally impossible. That the above and many other questions bearing upon the economy and efficiency of our shipyards are now occupying the serious consideration of many of our shipbuilders and shipyard managers is certain, but peace may come suddenly, and for the sake of the country and the benefit of individual firms it cannot be too strongly urged that every effort must now be made to anticipate and provide for the conditions of the future so far as the latter can be foreseen.

THE PYROGENESIS OF HYDROCARBONS.

The term "cracking" has become so popular that one feels momentarily uncertain almost whether or not a communication on "The Pyrogenesis of Hydrocarbons" will deal with the same reactions and processes which are conveniently indicated by cracking. The papers discussed in the Institution of Petroleum Technologists last Tuesday certainly did deal with cracking, and when we go systematically into the literature with Mr. E. L. Lomax, we soon learn that cracking, though generally assumed to date from the carelessness of a stillman, who left a big fire under a still in 1861, may be said to be as old as gas lighting itself. For Murdoch proposed to make illuminating gas from oil in 1792, before coal-gas lighting had really been adopted on any large scale, and Dalton cracked oil gas by electric sparks. Since then oil cracking has been studied and practised for different purposes, chiefly for preparing illuminating oils, permanent gas, aromatic hydrocarbons, and fuels for internal combustion engines. Every cracking process yields mixtures of these various products in different proportions, and the aims have at different times been to favour the preferential production of the one or other product, in accordance with the particular demands of the time. It would be unprofitable to attempt to classify the literature on the subject with respect to the chief aims in view, and Mr. E. Lawson Lomax, M.Sc., did not attempt to do so in the very able and complete historical and bibliographical review of the pyrogenesis of hydrocarbons which he gave on Tuesday last. This review formed Part I of the paper submitted. In Part II Messrs. A. E. Dunstan, D.Sc., and F. B. Thole, D.Sc., of the East Ham Technical College, discussed the general considerations of the pyrogenesis on broad lines. The communications were of considerable length, even without the full literature references which Mr. Lomax is going to add, and abstracting in the ordinary sense is out of the question.

Scientific investigation had begun long before Berthelot published his famous researches on the action of heat on various hydrocarbons in 1866. He started with acetylene, and concluded that at about 600 or 700 deg. C. the hydrocarbons reacted by direct affinity, and that they could all be synthesised from the lower members of a series. He also tried the opposite way, decomposing the higher hydrocarbons and mixtures of them by passing them through red-hot tubes, and subsequent research and practical work has proceeded on both these lines. The number of patents, researches, discoveries and rediscoveries is so large, the reactions are so complex and depend so much on circumstances, that we hesitate even to refer to the chief facts which Mr. Lomax accentuated in his rapid survey. The use of catalysts for the purpose of stimulating the

reactions in particular directions and of lowering the temperature at which they take place, goes back about 20 years. The use of compounds like anhydrous aluminium chloride to bind certain products, in particular unsaturated hydrocarbons, subsequently to be released again, dates further back, but has quite recently come to the front again. Heating oil alone, in the liquid or in the vapour phase, and heating oil and water or steam, have all been proposed over and over again. Since 1906, Mr. Lomax stated, over 60 patents have been taken especially for making motor fuel from oil. The novelty of many inventions cannot but be questionable under these circumstances. Mr. Lomax also questioned the novelty of some of the worked processes about which he was able to give certain particulars. Thus he pointed out that the identical apparatus of Sir Boverton Redwood and Sir James Dewar of years ago "would do the same work in exactly the same way that the Burton process of the Standard Oil Company is doing at present." The process "apparently being worked" was to distil petroleum residues for the production of low-boiling hydrocarbons of the paraffin series at a temperature of 650 to 850 deg. F., the whole plant being maintained at a pressure of 4 or 5 atmospheres by means of valves placed at the outlet of the condenser.

With regard to the Hall process,* probably the most successful being worked, Mr. Lomax remarked that the oil was passed up and down a continuous 1-in. coil, 600 ft. long, at temperatures and pressures to suit the desired product; the vapours were expanded at the exit into a wide tube, and this expansion down to atmospheric pressure was accompanied by an appreciable rise of temperature, owing partly to the conversion of the kinetic energy of the gas (at high speed) and partly to the disruption of the molecules of the oil; most of the cracking and some deposition of graphitic carbon took place at that stage. The vapours then passed through a series of Raschig dephlegmators and, cooled to 100 deg. C., entered the compressors. When working for motor spirit (at 550 to 600 deg. C. at the exit tube) this compression was accompanied by a slight fall of temperature, probably because some of the lighter hydrocarbons polymerised. The optimum temperature and the rate of feed for any particular reaction had to be maintained, and were maintained, within 5 per cent.; that was most important. When working for aromatic hydrocarbons the temperature and pressure were 750 deg. C. and 105 to 110 lb. per square inch; the spirit that had been made for 11 months (during which tubes had been run for 250 hours without requiring cleaning) in a large plant (views shown) contained up to 18.5 per cent. of benzene, 17.5 of toluene and 6 of xylene, with very little paraffin; the yields were good; 70 per cent of the oil could be obtained as motor spirit as mentioned.

The Rittman plant of the United States Bureau of Mines and the Aetna Company, which we described recently,† was criticised by Mr. Lomax. They had installed six furnaces, each of two rows of five cracking tubes, 11½ ft. high and 8 in. diameter, the furnace being heated by 22 gas burners. The tubes and their axial stirrer rods were unwieldy, the carbon deposits very troublesome; it was difficult to see how the stirrers could pass air-tight through the stuffing boxes at 700 deg. C. and 150 lb. per square inch; the oil vapour could not be properly and uniformly heated by passing through the tubes, and the claimed absolute control of temperature and pressure and the operating conditions looked very doubtful. The identification and estimation of the products obtained by the specific gravity tests seemed very unreliable, moreover, and the aromatic hydrocarbons prepared admittedly contained considerable quantities of non-aromatic bodies (not attacked by strong sulphuric acid); further, a Rittman plant to deal with 18,000 gallons of oil daily would require 60 tubes, costing 68,760*l.*, whilst a Hall plant of 10,000 gallons capacity would cost 12,000*l.* Mr. Lomax further stated that Rittman's claim to have discovered, or practically established, that any type of oil would yield aromatic hydrocarbons might equally well be raised by Mr. Hall. The priority question does not interest us, and the cost estimates are too hazy; most of the other criticisms seem justified, and Rittman himself admitted that faults had been committed. Mr. W. J. A. Butterfield remarked subsequently that the design of the furnace should have been entrusted to gas engineers and not to the academic staff of the Bureau; with tubes of 8 in. diameter radiation from the hot walls would play as important a part as it did in partly filled gas retorts. One of the main technical problems is certainly to provide for efficient, uniform heating of the vapours drawn through the tubes.

In presenting the "general considerations," Dr. Dunstan said that there was no lack of bones to build up the skeleton of the pyrogenesis, but the reactions were very complex. Giving the thermochemical data for a large number of reactions, he pointed out that the reactions proceeding by absorption of hydrogen were in the main exothermic, that is to say, the products formed contained less intrinsic energy than their generators and were more stable, whilst a genuine cracking (splitting-up) process was mostly endothermic, relatively unstable products (the unsaturated olefines) being formed which had a proportionately larger heat of combustion. The temperature coefficient of most of the reactions was surprisingly constant, but in changes of temperature, &c., the general law of Le Chatelier had to be borne in mind: When one or more of the factors determining an equilibrium were altered, the equilibrium was displaced in such a way as to neutralise the effect of the change. Hence, for instance, heat was liberated when carbon and hydrogen united to methane; when heat was admitted to this system the equilibrium was displaced in the direction that heat was absorbed and methane dissociated again. As regards reaction velocity, Dr. Dunstan quoted various examples: when 98 per cent. of methane was decomposed at 675 deg. C. in 6 hours, *e.g.*, the same decomposition would only take 5 minutes at 800 deg. C., and a fraction of a minute at 1,000 deg. The temperature at which cracking began depended upon the complexity of the molecule, the complex unsaturated compounds decomposing first; up to 500 or 600 deg. C. the resulting product would chiefly consist of olefines and paraffins; at 700 deg. of olefines, diolefines and aromatic bodies, with little paraffins; at 1,000 deg. mainly of permanent gases (methane and hydrogen) and a tar rich in aromatic hydrocarbons. These temperatures presumed atmospheric pressure. Increase of pressure in general raised the synthesis or combination, diminished pressure favoured dissociation. With respect to catalysis the iron tubes of the apparatus were often more effective probably than the nickel or other catalytic material put into them; the catalytic action was probably a surface effect, not a specific effect of the substance, and depended little on the nature of the metal or oxide used. In the catalytic effect of aluminium chloride the hydrolytic formation of hydrochloric acid was probably a factor.

Coming to the mechanism of the pyrogenesis, Dr. Dunstan took an intermediate standpoint between Berthelot, who accentuated polymerisation or condensation of simple molecules (especially of acetylene) to complex molecules, and Bone and Coward, who suggested a breaking-up of the molecules into nascent radicles which reunited sometimes to cyclic compounds. Total disruption might take place at high temperatures of 1,000 deg. C., but for temperatures of about 500 deg. he preferred the less drastic views of Thorp and Young and Haber. This exposition would lead us too far into strictly chemical problems, however. Dr. Dunstan concluded by showing a few experiments. Strong sulphuric acid binds the unsaturated hydrocarbons; when the acid was too strong, or the temperature too high, the reaction was so energetic that a tar was formed and an explosion might take place. By suitably grading the sulphuric acid treatment, however, Dr. Dunstan mentioned, Dr. Thole had succeeded in freeing the products entirely of the undesirable diolefines, which otherwise slowly separated out of the spirit as gums of an offensive smell and caused a great deal of trouble.

This was one of the chief points to which the discussion referred. Dr. W. B. Blackler mentioned that cracked motor spirit admitted of being mixed with half its volume of alcohol, the mixture boiling below 100 deg. C., although the constituents might run up to 250 deg., but the formation of the gums was very troublesome. He had, however, he added later, found a remedy for raw spirit which contained about 9 per cent. of diolefines; the treatment prevented the reoccurrence of the gums after months. Dr. Molliro Perkin, to whom Mr. Lomax had referred, said that he had, in conjunction with Mr. Fenchelle, heated the oil at so high a pressure (90 atmospheres) that it could not boil, and they had not been troubled with carbon deposits except when working with certain oils. But they had been disturbed by the gummy deposits. Treatment with 5 per cent. of sulphuric acid had removed the trouble for a time; but when the spirit was kept for months, the gums were apt to reappear and to stop up the valves. Petrol from the oilfields did not cause this nuisance, which no doubt could be overcome. Mr. E. W. Lucas, speaking as an engineer, thought that the rate of cooling the gas after cracking might be concerned in the gum trouble; different products might be formed, and no gums arise if the cooling were slow. He also said that he had found that an alloy of iron and manganese, prepared so as to resemble a sponge, made a very good catalyst. The catalytic efficiency of this alloy, which really behaved like a sponge, rose in a few weeks to a constant value, and then dropped off after months; the catalyst could then be regenerated by being heated, and the hydrocarbons it gave off in this distillation process depended upon the treatment the oil had undergone. We have already referred to Mr. Butterfield. He confirmed the concluding statement made by Dr. Dunstan, that the nature of the material to be cracked seemed to have little influence on the final products; he had recognised that 20 years ago. The practical demonstration of the fact seems, however, to have been left to the Bureau of Mines and to Mr. Hall. There is one more point from Dr. Dunstan's paper to be touched upon. Lunge, an authority on coal-tar, had rather scoffed at the attempts at making benzene from petroleum; that had been in peace time, and might become true again in peace time.

* See ENGINEERING, vol. xcix, page 250.
† See page 158 *ante*. See also vol. xcvi, page 124.

NOTES.

MINERS' PHTHISIS AND DUST.

THAT miners' phthisis is a special scourge, distinct from ordinary phthisis and attributable to the gritty dust raised in certain mines, has been understood for some time. A good many committees have investigated the problem during the past two decades, and they have fairly agreed upon the causes of this dreaded disease. So far as we know, however, it had not been pointed out before that it is the very finest invisible dust which is responsible, and this fact changes the whole aspect of the problem. The coarse dust is more or less avoidable, but not the fine dust. The conclusion just stated is drawn in "The General Report of the Miners' Phthisis Prevention Committee" of the Union of South Africa, which has reached us from the Government printing offices at Pretoria. The real report covers only 50 pages; together with the appendices on appliances, methods of investigation, &c., the report makes up a small quarto volume of nearly 200 pages, full of interesting matter. The committee has been deliberating, collecting evidence and experimenting since 1912; their work is being continued, and if the recommendations which they make be acted upon, the report ought to do some good. The injury caused by the dust is in the first instance mechanical; it irritates and wounds the mucous membranes and cilia of the nose and bronchial tubes, which arrest and eject, by coughing, the coarse particles, but which fail to afford protection when men continuously breathe air contaminated with very fine dust. Then silicosis is set up, the name indicating that silicious dust is chiefly concerned, this dust being common in the gold mines of the Witwatersrand, with which this report deals; any gritty dust is bad, of course. Silicosis, a condition of fibroid change in the lungs, is not infective; but as the illness advances, tuberculosis is generally superimposed, and the character of the disease then

becomes that of phthisis. Of 3,186 underground workers examined by the committee, 26 per cent. were found to suffer distinctly from silicosis, and 5.5 per cent. more were suspected of being affected by it. This is an awful percentage. Rock-drill men were in particular liable, but patients were found also among the office staff; the dust-laden atmosphere of the Rand endangers everybody. That it is the very finest dust which does the mischief they proved by X-ray and post-mortem examinations and by experiments with rats, &c. The coarse dust does not reach the lungs; the finest dust particles found in the lungs had a length of 1 or 2 μ (1 μ = 0.001 mm.) and were not grainy, but sharp edged; the red blood corpuscles are four times as large as these finest particles. To catch this dust in tests the air is sucked and filtered, not merely through water, but through a solution of sugar or potassium oxalate; filters of cotton wool are themselves apt to be dusty. The air is first passed through fine gauze (260-mesh), and the sugar solution is finally incinerated. The counting of the particles under the microscope—about which the report says little—shows that the number of the particles is far more important than their weight; 170,000,000 particles would weigh less than 3 milligrammes, and a person walking in a mine after the Sunday rest might inhale about 5,000,000 of these injurious particles per minute. Respirators are useless against such fine dust, and the report is in general doubtful about the utility of various cures and remedies. The only possible thing is dust prevention. That can mainly be effected, the committee believes, by water spraying and good ventilation. But the water should be clean, and the water spray should be kept on for at least an hour after general blasting which raises large amounts of dust.

Floats for Seaplanes.

In a paper recently read before the American Society of Naval Architects, Mr. H. C. Richardson describes some experiments undertaken to discover the best form of float for seaplanes. One of the difficulties met with in some forms of float, which would *a priori* be thought likely to be satisfactory, is a tendency to be drawn under water by the motion. This disability was particularly prominent in the case of one float, in which an attempt had been made to reduce the frictional resistance of the float to a minimum by giving it a parallel middle body with semicircular midship sections and ogival ends. At moderate speeds this form behaved admirably, but as the stage was approached at which the seaplane should rise into the air strong suction effects were experienced, as the result of which clouds of spray were lifted clear of the surface. To test the matter further, the model was counterweighted so as to have a zero load-line, the bottom being just in contact with the water. Nevertheless at the "get away" speed of the plane the suction developed was sufficient to drag the float down into the water till its deck was flush with the surface and a sheet of spray was lifted several feet into the air. The experiments were made with models, one-ninth full size, in the Washington Navy Yard, at speeds up to 15 knots, which corresponds to a speed of 45 knots for the full-sized float. The best floats so far tested are built up of two-ply wood, with cotton sheeting and marine glue between the plies. They have an approximately stream-line form and curved deck, and are strengthened by a longitudinal truss and two-ply partitions inside. The length is 15 ft., maximum beam 24 in., and maximum draught 14 in. The float is designed for 1,000 lb. displacement, and 60 per cent. reserve buoyancy, and its weight complete is 125 lb.

Hydrogen Producer for German Airships.

The Messerschmitt process is said to be exclusively used by the German military department for the production of hydrogen for their balloons and airships, and the process has recently also been introduced into the United States. It is owing to the latter circumstance probably that the journal *Metallurgical and Chemical Engineering*, of October 15, 1916, is able to give some particulars of the process and of German installations. In America the process is applied for generating hydrogen for the hydrogenation of oils. The process is one of those in which steam is decomposed by hot iron with the formation of hydrogen and of the oxide FeO, and the latter is subsequently reduced again to iron by water-gas. As theoretically the iron is not consumed in the reactions, the process has also been called a contact process; that term suggests catalysis, however, and is not well chosen, we think. A good many of these processes have not answered because the iron is attacked, and the conti ued operation of the apparatus is not easily controlled at economical rates; the hydrogen is not pure enough for some applications, moreover. Dr. Messerschmitt claims to have overcome many difficulties, and it is said that the German military department has erected 14 of his plants, ranging in capacity from 100 to 600 cub. m. per hour, and is increasing these plants. The generator is a cylindrical shaft, containing two concentric iron shells, designed to contain the iron reagent in the annular space between them. The inner cylinder or the space between the outer cylinder and the shaft is packed with bricks chequer fashion. The iron is filled in from the top, and emptied through manholes at the bottom. The operation proceeds in three stages or periods. The first is the heating and reduction period. Gases and air are separately sucked in at the bottom of the generator in such proportions that only partial combustion is possible; these gases pass through the fire bricks within the inner cylinder to the top of the generator, enter the iron mass, flow down through it, then heat the outer bricks and leave through the fan flue, escaping into the air; this period lasts 20 minutes. The supply of heat, of reducing gas and air is then cut off, and steam is blown in, again from below, for a few seconds; this is the second, steam or rinsing period. The fan flue is now closed, and steam is sent from the top into the outer chamber, from the bottom of which it enters the iron mass; the iron decomposes the steam, and hydrogen escapes from the annular space and the top of the inner chamber through a conduit provided with a water trap. The third, gas generation, period occupies 15 minutes. From the trap the hydrogen is sent through purifiers of iron ore and lime—to absorb any carbon dioxide, sulphur compounds, and other impurities—into the gas holder, from which it is drawn into the compressor. Photographs of some of the apparatus and sections of the generator are to be found in the Journal we quote, but there is not much detail. The manipulation of the generator is stated to be very simple. One man can attend to two generators, looking after the pyrometers and operating the levers by which the periods are changed. The contact mass will last a "long time." The temperature is so regulated that the iron mass keeps between 700 and 800 deg. C.; overheating would be bad, as the iron and oxide might begin to fuse and would no longer be ready to react. One boiler and water-gas producer (coke and steam) are said to suffice for several generators. The cost of the process depends chiefly on the cost of coke and other materials; in the United States one plant produces 1,000 cub. ft. of hydrogen at an average cost of 40 or 45 cents (about 20*d.* or 22½*d.*); this sum is to include investment, depreciation, materials and labour. The hydrogen generated is described as almost pure, of 99.2 per cent., containing only traces of nitrogen. The hydrogen is supplied in cylinders or is directly drawn from a kind of hydrant.

Engineering Works in Belgium.—A neutral commercial agent, who has just returned from Brussels, where he lived for several years, in an article in *The Times* reveals the present condition of Belgium. He states that "the metal and engineering trades have suffered worst of all. The great Cockerill Works at Seraing were taken over immediately after the fall of Liége. Since then all the iron, steel and electrical works in the Valley of the Meuse have fallen into German hands. M. Renson, director of the important Angleur Steel Works, who refused to conduct operations for the invader, was made prisoner and sent to Germany. The machinery of the International Electric Company and of several similar concerns has been carried across the Rhine. All stocks of copper and brass and enormous quantities of tools have also been commandeered. Thousands of skilled artisans were thrown out of work in consequence. Many factories which Belgians were trying to keep going have since been closed, because it is impossible to obtain lubricating oils for the engines and machines; and the latest requisitions of the German tyrant are for all the leather belting in the country. Idleness has, therefore, been forced on the people. The German statement that the workmen prefer to be maintained by public charity is not true."

LITERATURE.

Typographical Printing Surfaces: the Technology and Mechanism of their Production. By Lucien Alphonse Legros, Member of the Institution of Civil Engineers, and John Cameron Grant. London: Longmans, Green and Co. 1916. [Price 42*s.* net.]

Technical literature, which has been poured forth so abundantly of late years in order to explain to the uninitiated whatever is obscure in processes of which only the application or the final results are seen, has for some reason avoided the typographer's art, and the description of the steps that have led to the production of the printing surface, the approach to perfection of which has done so much to assist the making of books and the spread of information. The actual printed page and the methods of printing have appealed to a far larger circle of writers and readers, but the preparation and manipulation of type, the work of the compositor and the type founder, have attracted few exponents.

This neglect of a most important subject cannot have arisen from any lack of interest in the inventive skill displayed, in the nice adaptation of machinery employed, or in the delicacy of the operations involved, attaining in some directions the limit of human accuracy in manufacture. But till the advent of combinations of the casting, composing and line-adjusting machines, novelty was wanting, the processes adopted as a rule only differing in accuracy from those that have long been followed. In any case, the defect is now amply remedied. The authors of the valuable work now under review are most competently equipped for the heavy but evidently congenial task which they have carried out. They have personally taken active part in the promotion of some valuable patents connected with typography, and have had abundant opportunity for watching the progress of successive engineering applications devoted to the production and handling of type. The book affords, too, gratifying evidence of great care in securing accuracy and completeness of description of the mechanism employed, as well as of access to first-hand information. The result, involving much time and labour, is eminently satisfactory. Any weariness that might be experienced from the necessary length of the work is lightened by the introduction of welcome *obiter dicta* and suggestive references to matters just outside the scheme that the authors have defined for themselves and closely maintained.

The engraved block that from time immemorial has been used for registering impressions, and still finds employment in China and Japan for typographical purposes, accomplishes all that can be done by a printing surface. The scope for ingenuity lies in facilitating and accelerating the processes, reducing the expenses of production, and at the same time setting free human labour for other occupations. The generic improvement in facility of production, usually understood as the invention of printing, was effected by the use of movable types, an advance easy of accomplishment in languages possessing simple alphabets; but to obtain an impression for several blocks or dies grouped into a single unit involved no new principle. The difficulties were mainly mechanical, and the authors suggest that the want of a suitable vehicle for printing delayed progress quite as much as the failure to grasp the convenience of movable types. The thin, watery ink used in Europe in mediæval times would have collected in blotches on smooth paper, and the impression from an engraved block, or a collection of types, would have been irregular and illegible. Sufficient attention has not hitherto been given to the fortunate and contemporary discovery of the possibility of mixing colours with oil, a process that rendered the art of printing possible.

There is, however, a limit to the convenient use of movable types, and we are here tempted to follow the authors in one of those excursions, slightly off the beaten track, as interesting as they are legitimate, and which add so much to the value of the book. It may be prefaced that the work describes the mechanism used in recording language represented by Latin characters, and the founts of type which comprise the symbols that actually occur in books and papers. But the ambition of orthographers and linguists leads them to propose

schemes by which every articulate sound shall be recorded by an appropriate mark or sign. The effort to attain completeness and scientific accuracy has unfortunately outrun discretion, demanding such an increase of type forms as would alike perplex the compositor in setting and the reader in deciphering. The ordinary fount of type in commercial use to-day, embracing capitals and lower-case letters in Roman and italic character, with integers, accented letters, and peculiar signs, numbers some 275 pieces. These can give rise to sufficient complications, but even this number is utterly inadequate to meet the necessities of those who advocate the formation of universal international systems.

The Berlin Academy of Oriental Languages, for example, straining after thoroughness in order to represent the spoken sounds of a single language, would employ 45 vowels, each distinguished by an elaborate system of accents, the letter *a* appearing in no less than 13 different guises. The language represented is probably not more flexible than the English, which finds effective expression by simpler if less scientific means. Apparently the typographer has been consulted as little as the convenience of the reader, for it is not a simple matter to invent a new letter-sign that shall meet all requirements. The newcomer must satisfy the two primary conditions of distinctness and simplicity. It must be so differently shaped from any of the forms in use that its impression can be clearly perceived under unfavourable conditions of light, &c., and its outline must be sufficiently strong to enable the casting to stand the same treatment as the rest of the fount. These criteria have been found to be severe stumbling-blocks in the inventors' path.

We cannot say that we consider that the International Phonetic Association has been quite successful with the type employed, but at least the members have recognised the difficulty arising from the use of a multiplicity of symbols, and have sought to overcome one objection by eliminating all capital letters. This gives the page an unfamiliar appearance, but whether the use of the capital confers any advantage is a moot point. The authors quote with approval the conclusions drawn from many repeated experiments by Dr. Cattell, who decides that the use of two varieties of letters, capital and lower case, is more hurtful than of assistance to the eye and brain. This authority would strip all letters of ornamentation, as the serif, and employ only the simplest geometrical forms. The hair line is also condemned, and the general use of thick and thin lines in printing is gravely questioned as of doubtful benefit.

In the book before us the authors necessarily give very many specimens of different types, and the "Sanserif" would probably take the first place for clearness and decision, though the old-style face with thick hair line and a large radius connecting the serif with the main stroke has much to recommend it. We regret that no specimen is given of the Dutch type that Dr. Fell presented to the University of Oxford towards the end of the 17th century, of which the original matrices are occasionally used. A comparison with modern type would show how little has been effected in improved legibility. The designers of type seem in many instances rather to have studied artistic effect than distinctness of impression, though possibly some of the harsh criticisms that have been urged in this matter are not well founded.

Though regard for phonetic accuracy has led in some cases to the mistaken employment of an inconvenient number of characters, it is satisfactory to record that very considerable progress has been made in reducing the cumbersome notation which the Eastern nations employ as a medium for printed communication. The best-known instance is the elaborate system of pictorial ideographs in use among the Chinese, and we note with pleasure that in this reform the authors have played a prominent part by successfully introducing plans for simplifying the written language, and particularly in removing the disabilities that prevented the application of modern machine composition to Chinese script. The number of conventionalised pictures that do duty for movable types is probably not less than 30,000, certainly a number that effectually prevents the cutting of punches and the application of matrices to any form of machine. The method, of course, cannot be described here, but it is based on an improved syllabary that the Chinese have accepted for official purposes, of which the main feature is the division of each ideograph into two portions, one giving a fixed phonetic value, the other expressing the true value to be given to the whole composite character. Such a method may be of use in diminishing the number of forms to be memorised, but the difficulties in adapting the script to the typewriter or composing machine would still remain. The authors' invention removes the last difficulty. By mechanical and technical processes they have succeeded in arranging the phonetic and tonal signs in such a manner that, while preserving perfect naturalness and legibility to Chinese eyes, the composite phonographic character can be brought within range of a composing machine.

A complete system of romanisation is, however, likely to be adopted. The Japanese have travelled a long way in this direction, and that the Chinese will follow is indicated by the fact that a modified Braille system has been adapted for the use of the blind. For this purpose it has been necessary to place the Chinese language practically on an alphabetical basis, in which 50 radicals and 12 phonetics, used in combination with the tonal sign, can be made to represent correctly every sound in the official language. Each of these 62 radicals can be represented by an appropriate Braille sign. In the syllabary the combination of the six Braille dots suffices (the number of possible combinations is, of course, 64), but in the example of Chinese Braille, interlined with ideographic equivalents, the number and arrangement of the dots seems confusing to the inexpert. But that such a system can be systematised and made available is a great step, and one that Chinese patience will turn to good account. An admirable description of the Braille system as used in this country is given, and some possible improvements are suggested; but in respect of rapidity and exactness the recorded achievements show that there is little room for improvement. The authors have seen a letter taken down by a blind girl at the rate of 160 words a minute, read back by passing through the fingers at the same rate as ordinary written stenography is read back, and finally typed by the same girl, without a single error, on an ordinary typewriter.

It is but a short step from the Chinese characters of to-day to the hieroglyphic alphabets and complex sound syllables in use when the world was young. The cuniform script is set up without any difficulty, the em quad apparently sufficing for the most elaborate arrangement of wedge forms. The hieroglyphic MS. of the Eygptians seems to give a little more trouble in justification, but ingenious treatment has brought even these irregular symbols within the compass of movable type. The authors note the increased demand for a language, mute in itself, but which is a conveyor of meanings through the eye, and may be interpreted by every man into his own aural language in his own particular sound values, just as the motorist understands the caution signs on finger posts, or the physician recognises the uncouth symbols of a prescription. Whether any considerable future lies before this sign language cannot be foretold, but we are quite certain that the typographer will be equal to any demand that is made on his inventive powers.

We have lingered over these applications of typographical printing surfaces, for they indicate the varied character of the book, and suggest the number of interesting topics that are brought within its purview. But a still larger and, from a typographical point of view, more valuable section of the work is devoted to the manner in which relief type surfaces are prepared and utilised. The method of assembling the different types by hand, in one case, or by more or less automatic machinery in the other, leads to other evident sub-divisions, while the processes of stereotyping and the many ingenious devices that promote celerity and economy of production might well constitute a third section. The authors admit the difficulty they experienced in determining what to include and what to omit, and a similar hesitation is felt in attempting to follow them over a ground where the evidences of progress are so many and the ramifications so varied and fruitful.

In its conception and early application the process of printing is essentially simple, especially with wooden types as at first practised. The substitution of metal types introduces complications, for first a steel-cut punch is required from which to strike a matrix; next a mould, and, finally, the finished type has to be formed. Admirable work was accomplished by these simple tools, but commercial enterprise demanded greater rapidity and economy. The policy of hustle has been responsible for the exercise of much ingenuity. To it we owe those machines, whose variety is protean, which in connection with some form of type-casting mechanism produce a printing surface practically without the intervention of hand labour beyond the manipulation of a keyboard. Finally have been evolved the Monotype and Linotype classes of machine, in which are carried out all the possible combinations of composing, line justifying, type casting, and even distribution, if the word can be applied to the remelting of type, a plan contemplated by Church a century ago, but one whose economical advantages have only recently been admitted.

In all the manifold processes connected with the preparation of the typographical surface, whether as evidenced in the first operation of cutting the punch, or concealed in the marvellous complications of a modern Linotype machine, the one insistent feature is the accuracy of workmanship. The microscope and the micrometer are the constant companions of the punch cutter, but these would not prove sufficient unless the workman possesses the artistic ability to produce the correct curves and the manual dexterity that enables him to work to the nicety of 0.0003 in. Indeed, compared with some measurements given, this degree of accuracy seems inadequate, for we are told that the adopted size of standard pica type is 0.166044 in. and that the unit point is 0.013837 in. ! We appear to be measuring the wave-length of light rather than a piece of metal that has to be submitted to rough usage in varied temperatures, and we wonder whether the authors ever represented to themselves the significance of the last decimal integer. Let us hasten to add, however, that the accuracy attained is marvellous, and does not seem to admit of improvement. We may be thankful that these competent artists do not turn their attention to forgery, they would have a *succès fou*.

By way of showing the wonderful accuracy and interchangeability of type made by different founders, the authors offer an example of four stanzas each one of which is set up by a different mixture of type from three selected foundries. In one type A is used, in another A and B mixed, in a third A and C, and in the fourth is a combination of A, B and C. The riddle is to determine which stanza is the product of one foundry, and in what way the others have been mixed. Assisted by considerable magnification, we failed to solve the puzzle, but we failed in good company, for the compositor who set the verses could not decide otherwise than by looking at the back of the forme. We cannot sufficiently admire the faithfulness to the original design, "the accuracy of the justifiers in positioning the characters, the accuracy of the mould makers in the construction and finish of their moulds, and generally the smallness of the total error resulting from the combination of the many different processes which are applied in the production of a type, even when carried out independently by different firms with different workpeople and under different conditions." Just one word more, the type used in this specimen was cast in a single mould at the rate of 160 letters per minute.

It is the authors' task to describe how the accumulated experience of the ages has made such a miracle possible. We will merely say that they have brought their special contribution to the common stock in the form of a punch-cutting machine, which, among other advantages, permits microscopic examination while the work is in progress, a very necessary adjunct. To attempt to follow them through the bewildering mysteries of matrices and moulds and pumps without the aid of illustrations would be both ridiculous and unedifying. Sufficient to say that the reader will find himself led

by the hand of a master who raises difficulties to show how they have been surmounted, and keeps the main motive prominently in view notwithstanding the perplexities of detail.

But at this stage the reader is only at the threshold of the subject. He has learnt to appreciate the care necessary for the conduct of a simple operation, but he has yet to learn how to combine several operations in one machine, and to preserve the same accuracy through all operations. There are four main processes that have to be considered: casting, composing, line justification, and distribution, and the authors discuss every possible combination of these operations, taking two, three or four together. The distribution can generally be omitted, for, as we have said, the cheapest and best way to distribute is through the melting pot.

However, after possible exclusions there remain 12 combinations, a number that is made almost infinitely greater by the various expedients introduced by different inventors to effect the same purpose. In its most capable form the completed mechanism seems to be consciously intelligent in its action, especially in the matter of "justification," an adjustment that is brought quite within the compass of automatic accomplishment on more than one machine. In the Linotype machine and its derivatives, whose distinguishing feature is the production of a "slug" or a line of type at a single operation of casting, the entire operation of composing and justifying is carried on at the rate of about 10,000 ens per hour. In the Monotype variety, as the name indicates, every letter is cast successively as the final result of a series of operations, and the casting and composition are usually kept distinct and separate. The speed of working is about the same, 150 types per minute being a good average. The "slug" machines have some disadvantages, particularly when corrections are needed, and the advantages of the loose type machine are becoming better appreciated. On these two main classes, various monographs have appeared, and the details set out more fully than in the present volume. But the particular value of the authors' work lies in the facility for contrasts it affords between competing machines: the clearness of description due to the intimate knowledge of the writers; and the varied and excellent illustrations lavishly provided. Among technical works it should certainly take a very high place, both on account of its abiding interest, and the quantity and variety of information included in its pages.

Concentrating Ores by Flotation. By THEODORE J. HOOVER. Third Edition. London, 1916: *The Mining Magazine*, the Technical Bookshop, Salisbury House, E.C. [Price 12*s.* 9*d.* net.]

The Flotation Process. Compiled and Edited by T. A. RICKARD. First Edition. San Francisco: *Mining and Scientific Press*; London: *The Mining Magazine.* [Price 8*s.* 6*d.* net.]

THE two volumes before us discuss, each in its way, the same important subject on which there is hardly any book literature. Both the authors deal with the whole problem; broadly speaking, one might say that Mr. Hoover dwells more on Australian practice, and Mr. Rickard on what has been done in America. These are the two countries in which flotation processes have taken their chief developments. Australia was earlier in the field, though the early history of the problem points rather to England and America. Both the books have their merits. Our notices will be brief, as we dealt at length with the theoretical and practical aspects of flotation in our issue of August 25 last. We will begin with Mr. Hoover's book.

Mr. T. J. Hoover is a graduate of the Leland Stanford University of California, a mining engineer who worked in Australia, lives in London, and stands historically in the front line of expert authors on flotation. The first edition of his book appeared in 1912, the second in 1914, and a supplementary chapter has been added to this third edition, and the bibliography brought up to date. This bibliography is a strong feature of the work; it notices everything that has been written on ore flotation and its principles in the proceedings of technical societies, in the patent records, and in scientific and technical publications, from articles of several columns down to paragraphs of a few lines, the length of each article being stated. It will be understood that this bibliography takes up a considerable portion of the 307 octavo pages of the book. Mr. Hoover acknowledges his indebtedness to the members of his former staff and to Messrs. H. Livingstone Sulman and Hugh F. K. Picard and the directors of Minerals Separation, Limited. He describes his book, in the complete title, as a Description and History of a Recent Metallurgical Development together with a Summary of Patents and Litigation, and those words well characterise the volume. After an historical sketch on flotation, he gives a list of patents, expired and unexpired, arranged as to dates, passes to a chapter on litigation—which has, of course, often been less fruitful to inventors than to other people—and on the theories of flotation, and the tests that should precede the adoption of any process. Then follow chapters on the processes of Potter-Delprat, de Bavay, Elmore, and many others, each one paying regard to technical difficulties, apparatus, working costs, recovery realised; a further chapter on economics, and the bibliography and supplementary chapter. The chapter on economics contains some things that one might look for under special headings; for instance, the notes on selective or preferential flotation (separation of one ore from another, not from the gangue) and application of the processes to gold ores, trouble with subsequent cyanidation, &c. Though the book is not free from repetitions and a little prolix on the early patents, the expert knowledge of the author (himself among the inventors) and the systematic treatment adopted recommend the book strongly.

Mr. T. A. Rickard, A.R.S.M., like Mr. Hoover a member of the Institution of Mining and Metallurgy and of the American Institute of Mining Engineers, is editor of the *Mining and Scientific Press*, and the book is a reproduction of articles published in that journal in the period July, 1915, to March, 1916—the date of the preface. The fact that these reprints, with a glossary, a table of contents and an index (4 pages) make up an octavo volume of 364 pages is sufficiently characteristic of the astounding development of flotation processes in America, where they had hardly gained a footing in 1912, whilst fully 50,000 tons of ores are estimated to be now treated daily by some flotation process in the States. The book is dedicated to Francis E. Elmore and Alexander S. Elmore, "in recognition of their persistence and engineering skill in the development of the flotation process." The chief authors are the editor (who opens the volume with a very acceptable general introduction on flotation and contributes also other articles), Messrs. O. C. Ralston (Preferential Flotation, Testing Ores for Flotation—this latter together with Glenn L. Allen), C. T. Durell, Dudley Norris, W. H. Coghill, T. M. Bains (Electrical Theory of Flotation), C. Butters and J. E. Clennell (Flotation of Gold Ores, Cyanidation); J. M. Callow (his process, Copper Ores), and F. A. Fahrenwald (Electrostatics of Flotation). Articles dealing with particular plants are by Messrs. W. Motherwell (Mount Morgan Mines; Inspiration Mine, Arizona); E. P. Mathewson (Washoe Works, Anaconda); J. Hebbard (Central Mine, Broken Hill, dated 1913, however), and an anonymous article on a Mexican mill plant. Some of these articles are very good. That they are of very unequal merit and that they often overlap are natural consequences of the history of the compilation. That an article headed "Air Froth Flotation" is an epitome of the speeches delivered in the lawsuit Minerals Separation, Limited, *v.* Miami Copper Company, by the two counsels for the complainant should have been stated in the table of contents. The misprint J. J. Thompson (with "p") might also have struck somebody; but mistakes once passed frequently remain overlooked.

BOOKS RECEIVED.

University of Texas. Bulletin No. 365. *Scientific Series No.* 29. *The Mineral Resources of Texas.* By WILLIAM B. PHILLIPS. Austin Texas: The University.

Proceedings, Incorporated Municipal Electrical Association, 1916. London and Reading: Wyman and Sons, Limited. [Price 5*s.* net.]

Engineering Applications of Higher Mathematics. By V. KARAPETOFF. *Part II—Problems on Hydraulics. Part III—Problems on Thermodynamics. Part IV—Problems on Mechanics of Materials. Part V—Problems on Electrical Engineering.* New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 3*s.* net, each part.]

United States Geological Survey. Water-Supply Papers: No. 340–L: *Stream Gauging Stations and Publications relating to Water Resources*, 1885 *to* 1913. Part XII.: *North Pacific Slope Drainage Basins.* Compiled by B. D. WOOD. No. 352: *Surface Water Supply of the United States*, 1913. Part II: *South Atlantic and Eastern Gulf of Mexico Basins.* NATHAN C. GROVER, Chief Hydraulic Engineer. No. 355: *Surface Water Supply of the United States for the year ending September* 30, 1913. Part V: *Hudson Bay Basins and Upper Mississippi River.* NATHAN C. GROVER, Chief Hydraulic Engineer. No. 370: *Surface Water Supply of Oregon*, 1878–1910. By F. F. HENSHAW and H. J. DEAN. No. 371: *Equipment for Current-Meter Gauging Stations.* By G. J. LYON. No. 375–D: *Ground Water in Big Smoky Valley, Nevada.* By O. E. MEINZER. No. 375–E: *A Method of Correcting River Discharge for a Changing Stage.* By BENJAMIN E. JONES. No. 375–F: *Conditions requiring the Use of Automatic Gauges in obtaining Records of Stream Flow.* By C. H. PIERCE. No. 376: *Profile Surveys of Chelan and Methow River Basins, Washington.* Prepared under the direction of R. B. MARSHALL, Chief Geographer. No. 377: *Profile Surveys of Spokane River Basin, Washington, and John Day River Basin, Oregon.* Prepared under the direction of R. B. MARSHALL, Chief Geographer. No. 378: *Profile Surveys in* 1914 *on Middle Fork of Williamette River and White River, Oregon.* Prepared under the direction of R. B. MARSHALL, Chief Geographer. No. 379: *Profile Surveys in* 1914 *in Umpqua River Basin, Oregon.* Prepared under the direction of R. B. MARSHALL, Chief Geographer. No. 388: *Surface Water Supply of the United States*, 1914. Part VIII: *Western Gulf of Mexico Basins.* NATHAN C. GROVER, Chief Hydraulic Engineer. Washington: Government Printing Office.

Aeronautical Engines: A Critical Survey of Current Practice, with Special Reference to the Balancing of Inertia Forces. By FRANCIS JOHN KEAN. London: E. and F. N Spon; New York: Spon and Chamberlain. [Price 6*s.* net.]

British and Foreign Marbles and other Ornamental Stones: A Descriptive Catalogue of the Specimens in the Sedgwick Museum, Cambridge. By JOHN WATSON. Cambridge, London and Edinburgh: Cambridge University Press. [Price 5*s.* net.]

An Introduction to Mine Surveying for Surveyors and Students of Coal Mining. By THOMAS BRYSON and GEORGE M. CHAMBERS. London: Edward Arnold. [Price 5*s.*]

Dynamo and Motor Attendants and their Machines. By FRANK BROADBENT. Eighth Edition, Revised and Enlarged. London: S. Rentell and Co., Limited, 36, Maiden-lane, W.C. [Price 2*s.* 6*d.* net.]

The Coming Crash of Peace and Britain's Mechanical Renaissance. By T. C. ELDER. London: Simpkin, Marshall, Hamilton, Kent and Co., Limited. [Price 2*s.* net.]

Eclipse or Empire? By HERBERT BRANSTON GRAY, D.D.Oxon., and SAMUEL TURNER. London: Nisbet and Co., Limited. [Price 2*s.* net.]

Excess Profits Duty and Profits of Controlled Establishments. By ERNEST EVAN SPICER, F.C.A., and ERNEST C. PEGLER, F.C.A. Second Edition, revised and enlarged. London: H. Foulks Lynch and Co. [Price 6*s.* net.]

The Fan, including the Theory and Practice of Centrifugal and Axial Fans. By CHARLES A. INNES (Cantab.). Revised by W. M. WALLACE, Wh.Sc., and F. RABY JOLLEY, M.Sc.Tech. London: The Technical Publishing Company, Limited. [Price 8*s.* 6*d.* net.]

The Development of English Building Construction. By C. F. INNOCENT. Cambridge: The University Press. [Price 10*s.* 6*d.* net.]

Bases Théoreques de l'Aéronautique. Aérodynamique: Cours professé a l'Ecole Imperiale Technique de Moscow. Par N. JOUKOWSKI. Traduit du Russe par S. DRZEWIECKI, Ingenieur. Paris: Gauthier-Villars et Cie. [Price 11 francs.]

L'Industrie de l'Acier en France. Par J. TRIBOT-LASPIERE. Paris: Librairie Vuibert.

Stresses in Wire-Wrapped Guns and in Gun-Carriages. By LIEUTENANT-COLONEL COLDEN L'H. RUGGLES. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 12*s.* 6*d.* net.]

The Indicator Handbook: A Practical Manual for Engineers. By CHARLES N. PICKWORTH, Wh.Sc. Part I. *The Indicator: its Construction and Application.* Fifth Edition. Manchester: Emmott and Co., Limited. [Price 3*s.* net.[

A METRIC READY-RECKONER.—Messrs. Edward Le Bas and Co., of Dock House, Billiter-street, E.C., have sent us a conveniently arranged set of tables for the interconversion of British and metric units. The tables are clearly printed on a stout card, coloured inks being used to facilitate ease of reference. They will certainly prove useful and handy to many.

UNITED STATES STEEL CORPORATION.—The net earnings of the United States Steel Corporation for the quarter ended September 30, after deduction of the amount required to provide for bond interest and redemption, were 69,601,175 dols., as compared with 24,342,160 dols. in the corresponding three months of 1915. The amount distributed in dividends for the September quarter this year was 17,741,725 dols., against 6,304,919 dols. in the corresponding three months of 1915. The total return this year upon the common or ordinary stock has been 7 per cent. A year since the common stock dividend was passed. The net earnings of the corporation for the first nine months of this year were 227,656,739 dols., against 79,118,548 dols. in the corresponding period of 1915.

"SPARK IGNITION."

To the Editor of Engineering.

Sir,—I have read with interest Mr. Gullette's letter in your issue of the 17th inst., but am not sure that I understand the object with which it was written. The words "laboratory research does not always agree with actual working conditions" may imply either that the conclusions expressed in my article are not in accordance with the facts observed in the engine tests cited, or that those conclusions provide an unusual instance of agreement. Further, Mr. Gullette says, "the figures (given in his table) are eloquent and require no embellishment." Does he mean that they show the futility of carrying out spark efficiency tests on an engine? If so, I quite agree with him.

The figures given show that a certain engine gave better results with magneto ignition than with battery ignition. There is obviously no inconsistency between this and any statement in my article. They represent a particular case which is covered by my conclusions. The figures would be interesting in an investigation of the suitability of a particular type of ignition mechanism for a given engine, but they have no value in determining the conditions which control spark ignition, because they have no bearing on the problem. No information is given as to the type of battery ignition mechanism employed, but from tests I have made on such a mechanism I should have expected an engine to behave as indicated by the figures, for the reason that the energy of the sparks from that battery system diminishes with the speed, whilst the energy of magneto sparks increases. Evidently in the tests recorded the mixture had to be made more explosive at the high speeds to keep the engine going when using battery ignition, owing to the weakening of the sparks.

As above stated this result is covered by the conclusions given in my article.

Yours faithfully,
J. D. Morgan.

The Marks and Clerk Laboratory, 13, Temple-street, Birmingham, November 20, 1916.

TRIALS ON A DIESEL ENGINE.

To the Editor of Engineering.

Sir,—In your issue of October 27, under the above heading, Professor Burstall, in introducing a paper by the late Mr. F. Trevor Wilkins, states in regard to the trial that the full load in the case of the engine considered represented the maximum amount of oil that can be put into that engine with an increase in the effective pressure on the indicator diagrams. I would like to know how Professor Burstall has arrived at this conclusion.

It might be possible that the engine stated, with a mean pressure of 86.15 lb. per square inch, was beginning to show smoke in the exhaust, but has it never occurred to Professor Burstall that this might be due to a bad adjustment of the engine—either the wrong position of the fuel cam, or the pulverizer not being suitable for the special kind of light paraffin oil used under the trials, and not at all in a missing surplus of air necessary for the combustion of the oil, as suggested.

As a matter of fact, the engine in question would first have its full load at a mean pressure of or about 100 lb. per square inch, and overload at 120 lb. per square inch. (In these figures are not considered the brake horse-power of the engine, which is stated to be eight, which is on the safe side.) It is a pity that nothing was done before so painstaking a trial to ensure that the engine was in order and giving perfect diagrams. This would have been quite an easy matter if they had taken the trouble to ask advice from one or other of the Diesel engine makers in this country. It is very interesting to see the results of a careful test, but very disappointing to see same carried out with a badly-adjusted engine; diagrams like the sample shown from the trial would not be considered good by any maker.

Further, it is a pity that the figures given in the trial results have not been more carefully checked; a great many of the figures are wrong. The piston-swept volume and clearance space given are not right, considering the figures stated of the engine dimensions, and these again influence other figures.

Things like this could be avoided by a little interest in the matter; but that is just the point, for, as Professor Burstall says, he himself does not believe in the Diesel engine. A funny expression! very often to be heard over here, but I do not think you will ever hear it from a scientific man on the Continent. If a scientist were asked his opinion, he would say that the Diesel engine is the engine with the highest thermal efficiency he knows of so far, and the matter would end there. As to the future of any particular engine—be it steam, gas or oil as the prime mover—he surely would not like to state definitely, as he knows matters sometimes move beyond his knowledge, and he has seen before now, from time to time, that the opinion of the scientist has been defeated in the end.

Yours faithfully,
N. Mickelsen.

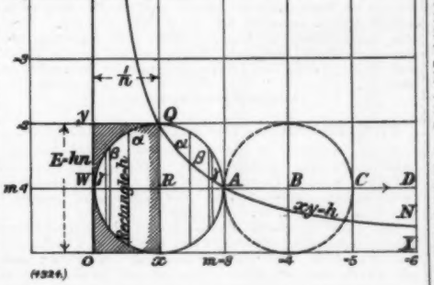
Hyndland, Glasgow, November 20, 1916.

ELECTRON, QUANTA AND RELATIVITY THEORIES.

To the Editor of Engineering.

Sir,—As one of the correspondents referred to by "Sesamy" in your issue of November 17 I shall be obliged if you will publish the enclosed original diagram co-ordinating and interpreting the various mathematical truths established by widely different schools in the theory of radiation.

Let the line OX represent time in fractions of a second; and let RW, the radius of a sphere, be equal to the wave-length known as 3646.1, corresponding to the convergence frequency of the hydrogen series. Let the duplicate transverse chords α, β, γ, &c., be equal to the respective wave-lengths of the transverse vibrations of the Balmer series, and the diameter $xQ = 7292.2$ a constant for all series. Let the line Oy represent the amount of energy or momentum E entering at W in the direction of WD. The hyperbola MN is the locus of a series of rectangles as Ox, Qy, representing the constant h and its equation is $xy = h$. Now $h = 6.6 \times 10^{-27}$ ergs $\times$ by seconds ("Report on Radiation and the Quantum Theory," J. H. Jeans, 1914), and $n =$ number of vibrations $\div$ by seconds in the equation $E = hn$, so that the time cancels out and the energy at any point is therefore instantaneous. The momentum E entering at W travels with the speed or light. This momentum or energy is identical in amount at any point of the line WD, but spreads out transversely to the limit 7292.2 at the light-node R, where xQ represents the limiting diameter of any discrete beam of light which vanishes at the alternate nodes AC, &c.; but the light-node A is in the trough of an electro-magnetic wave, emanating from R, and having its crest at B. The spherical elastic disturbance emanating from R represents the electron of uniform wave length so long as it remains spherical. Balmer's formula for the wave-length of α, β, γ, &c., is $\lambda = 3646.14\ m^2/m^2 - 4$. Let $m =$ OW or Ox consecutively numbered parallel to OX, OY. The squares on these lines represent the increasing sectional area of the light-wave supposing the ether to be a continuum, but the transverse ether vibrations



represented by α, β, γ, &c., occur at the same instant that the longitudinal heat pulse has reached A, B, C, &c., respectively. The duplicate plane transverse vibrations α, β, γ, &c., are thus equal and opposite reactions to every consecutive double heat-wave on both sides of any given pulse and the chord in the plane of polarisation represents Maxwell's displacement with Osborne Reynolds' negative displacement at the centre. The form of the composite wave becomes ellipsoidal for greater or lesser convergence frequencies.

Sir J. J. Thomson at his concluding lecture on "Radiations from Atoms and Electrons" at the Royal Institution on April 15 last exhibited the Stark effect on series spectra, and this was illustrated in *Engineering* of April 21. The α line is single as its reactive momentum only travels from the adjacent node A. The β line momentum travels from the node B, but also crosses the node A, thus producing two components. The γ line momentum travels from the node C, but crosses two other nodes, B and A, producing three components. Similarly, the δ line has four components, while Lo Surdo has shown that the fifth line has five components. The two sets of components are due to different times of the reactions on opposite sides of the node R and likewise the 27 visible lines of H γ in your article "Homogeneity of Visible Radiation" in your issue of November 17.

The total heat-energy of a series spectrum is the sum of the corresponding series of energy ordinates for the various wave-lengths, and this is always the sum of a Fourier series as $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4}$, &c., where the denominator of every fraction is the number of the respective components due to the Stark effect. There is thus a longer longitudinal heat-ray complementary to every transverse light vibration. Hitherto a Fourier series has been considered to be a mathematical artifice for analysing wave-motion but is here shown to have a sound physical basis.

Wien's fifth-power law must have a simple physical interpretation such as the product of the square root of the atomic weight multiplied by the cube root of the atomic volume, while Stefan's fourth-power law is the summation of this fifth-power series, but is complicated by the fact that radiation originates not only from atoms and molecules but also, at low temperatures, from molecular complexes. In fact, the whole diagram can be transferred from ether to water, for instance with a correction for velocity of propagation.

The base of the rectangle h tends to vanish with X-ray heat wave-lengths and action-quanta represented by the rectangle would not greatly differ from energy-quanta represented by the vertical dimension E which tends to infinity along the vertical arm of the hyperbola as the heat wave-length shortens.

I quite appreciate Sesamy's point of view, having myself spent 20 years in trying to fathom these subjects which engineers and amateurs alike have ceased to discuss; but it is quite useless to abuse even the relativist because we cannot understand his point of view. He is obviously on the scent of a truth which we shall only appreciate when Maxwell's and Reynolds' material theories of electricity and ether replace the present-day electrical theory of matter. Reynolds deals, in my opinion, only with the tension-surfaces which differentiate matter from ether, and not with the chemical atoms. I fear I have already transgressed the limits of a letter.

Fred. G. Edwards.

33, St. Ronans-road, Sheffield, November 18, 1916.

THE PRUSSIAN CROWN COAL MINES.

After about 12 years' patient waiting, and several unsuccessful attempts, the Prussian Crown has at last succeeded in becoming possessed of the whole of the important and much coveted Hibernia coal mining concern. The Crown mines in the Recklinghausen district alone represent some 200,000,000 marks, and the Hibernia now means a second Westphalian concern, representing probably some 160,000,000 marks. As a result the Prussian Crown now heads the list as regards allotment within the Rheinish-Westphalian coal syndicate, with an aggregate annual production of 11,813,500 tons for the first year, the quantity further increasing some 800,000 tons during the following years.

The story of the efforts of the Prussian Crown to expand its coal mining possession dates as far back as 1904, the Minister of Commerce at the time, Herr Möller, endeavouring to secure the Hibernia concern, next to Gelsenkischen and Harpen, the largest German coal mining concerns. When it became known that the Crown was willing to pay a price of 245 per cent. for the Hibernia shares, and the manœuvring of the Bank acting for the Crown became apparent, the holders of 30,000,000 marks shares in the Hibernia combined to frustrate the plan. The share capital was then only 53,500,000 marks, and the Crown had only acquired 20,000,000 marks, which amount had since increased to 27,500,000 marks. The bulk of the shareholders, unwilling to part with their shares to the Crown, formed a separate financial concern, the Herne Company, which held and controlled the Hibernia shares in question. After protracted litigation this Herne combine succeeded in holding their own against the endeavours of the other side to upset some of the arrangements in question.

The Crown, after repeated attempts during the last two or three years, has now at last become possessed of the coveted property altogether, through the purchase of 23,530,000 marks of ordinary shares and 10,000,000 marks preference shares of the Herne Trust, and 8,500,000 marks ordinary shares in the possession of the families Hamel, von Krüger, and others. The 27,500,000 marks shares originally acquired at 245 per cent. now stand at 218 per cent. The terms of the purchase now effected have not transpired in detail, but the price will probably average a somewhat higher figure than in 1904. It must, however, be borne in mind, that important industrial-political considerations have weighed heavily in this connection, the Crown desiring to augment and consolidate its position and influence within the coal syndicate, or, in fact, in regards to the German coal trade. A few hundred thousand marks of Hibernia shares still remain in private possession, but this is immaterial, the more so as it is understood that the Crown contemplates retaining the limited company form of the Hibernia and the present management and staff.

Great Pipe Contract.—The United States Cast Iron Pipe and Foundry Company has booked a contract with the Argentine Government for 66,000 tons of cast-iron pipe. The contract was taken at 13*l.* 5*s.* 6*d.* per ton. The largest pipes are 3 ft. 8 in. in diameter. Shipments to Buenos Ayres will be commenced early in 1917. The contract is twice as large as one placed with a British company a few months since for Argentina; this contract had to be declined by the American company as it was not then able to meet the delivery requirements insisted upon. The pipes now ordered are to be distributed among several Argentine municipalities.

The Work of the Imperial Institute.—It is too little known that the Imperial Institute, of South Kensington, S.W., issues a quarterly record of progress in tropical agriculture and industries and in the commercial utilisation of the natural resources of the Colonies and India. This quarterly Bulletin is edited by the director of the Institute, Professor Dunstan, F.R.S., and prepared by the scientific and technical staff of the Institute and by other contributors; it is published (at 2*s.* 6*d.* a copy) by Mr John Murray. The Bulletin contains, in addition to the records mentioned, also notes, reports and notices of recent books and papers concerning the development of natural resources. The Institute also issues pamphlets and monographs on various subjects compiled by the scientific and technical research department. The technical information bureau of the Institute supplies British merchants, manufacturers and others with trustworthy technical information regarding the sources and applications of industrial raw materials of all kinds, especially those derived from the British Colonies and India. The research work is chiefly initiated by the Government departments; but investigations are also conducted for firms and private persons on application to the director. The Exhibition Galleries of the Institute are open free every day. During the recent discussion on "Refractory Materials" Mr. T. Crook, of the Imperial Institute, was able to exhibit a rich collection of raw materials from these galleries, as we mentioned in our notice of this discussion.

KEADBY BRIDGE.*

By James Benjamin Ball, M.Inst.C.E.

The Great Central Railway Company have recently completed an important bridge over the River Trent at Keadby, about 14 miles north of Gainsborough, of which the chief feature is a lifting span, built on the Scherzer principle, which claims the distinction of being the heaviest lifting bridge yet constructed in Europe. The new bridge replaces the old swing bridge at Keadby which has carried the railway for over 60 years, and in addition carries a public highway in satisfaction of a long-felt want.

The new structure† consists of a combined railway and roadway bridge of five spans of the following dimensions:—Two fixed river spans of 135 ft. each; a lifting span of 160 ft., giving a clear waterway of 150 ft.; a track span of 40 ft. on which the lifting span rolls, and an approach span of 70 ft. on the east bank of the river.

The bridge has a width of 53 ft. 6 in. between the centres of the outside girders, of which 29 ft. 3 in. is occupied by the railway and 24 ft. 3 in. by the roadway; each span consisting of three main girders, the centre one dividing the roadway from the railway.

The river piers, of which there are four, are faced with granite and founded on rectangular steel caissons filled with concrete and sunk under compressed air to a depth of 50 ft. below low water. The largest of these caissons has an overall length of 94 ft., a width over cutting edges of 20 ft. and a permanent height of 32 ft. Difficulty was encountered in the early stages of sinking through one of the caissons tilting forward and moving bodily towards the river, which threatened serious results, but steps were taken which proved effective in arresting any further movement, and the caisson was finally righted during sinking in the new position it had taken up.

The two fixed river spans are similar in design, the main girders being of the ordinary N type, 17 ft. in depth, divided into 10 panels and counterbraced in the two centre bays. The cross girders are suspended from the vertical posts below the bottom booms and spaced 13 ft. 6 in. apart; between them ordinary roadway and railway stringers carry the deck plating. The top booms are connected by portal bracings at each vertical post, intersected by diagonal wind-bracing, and provision for longitudinal expansion is made at the junction of the spans by means of cast-steel bearings mounted on groups of rollers. The total weight of steelwork in each of these spans is 540 tons.

The three main girders of the track span form a path on which the lifting span rolls, and together have to sustain the weight of the lifting span, which is nearly 3,000 tons. These girders, which are of very heavy construction, have an effective length of 40 ft. and a depth of 10 ft., and carry on their upper flanges cast-steel plates, 3½ in. thick, on which the teeth are formed, engaging with corresponding slots in the segmental girders of the lifting span.

Considerable attention was given in the design of the bridge to the question of the contact pressures obtaining between the segmental girders and the track plates upon which they roll, and for the purpose of determining the probable are of contact careful experiments were made, particulars of which are recorded in the paper.

The lifting span consists of three main trusses spaced at the same distances from one another as the main girders in the fixed spans, and tapering from a depth of 36 ft. at the rear end to 18 ft. at the fore end. Cross girders, spaced 19 ft. 8¼ in. apart, with longitudinal stringers between them, carry the deck plating of the road and railway respectively, whilst the upper booms of the trusses are connected together by substantial overhead portal bracing on each of the vertical posts, which, together with the wind-bracing above and the floor members below, tie the trusses together, thus securing rigidity in the span as a whole.

The lifting span is counterweighted at the rear end in order to secure balance at all angles of lift, the counterweight consisting of a rectangular steel shell extending across the full width of the bridge, and heavily braced internally by lattice frames and strengthening girders. Its internal capacity is 24,780 cubic ft., and it contains 1,800 tons of concrete.

Between the rear ends of the trusses and the under side of the counterweight compound plate-web segmental girders having a radius of 28 ft. are provided. These girders have a central depth of 10 ft., and on their bottom flanges are bolted segmental plates of forged steel 3½ in. thick, provided with slots to engage with the teeth of the track plates on which they roll.

On either side of the lifting span heavy frames are built up alongside the track girders and anchored down to the supporting piers of the bridge. These frames at their upper extremity carry horizontal girders to which are bolted the main operating racks. Between these frames sufficient clearance allows the span to move freely as the bridge is raised or lowered.

The position of the racks coincides with the centre of the rolling circle of which the segmental girders form part, and the rotation of the pinions attached to the gudgeon pins of the moving leaf as they travel horizontally along the racks rolls the leaf backwards or forwards, so opening or closing the bridge. A horizontal platform at the level of the fixed racks is constructed on the leaf itself, and on this platform the lifting machinery is accommodated. The total weight of steelwork in the lifting span is 987 tons, exclusive of the machinery and gearing, and the total weight of the moving span, together with its counterweight, is approximately 2,020 tons.

The lifting span is worked electrically by means of two 115-h.p. direct-current motors, carried on the leaf itself, the power being transmitted through trains of gearing to the main pinions on each side. The angle of maximum elevation of the bridge when fully open is 81°51, and the time taken to open or close it by electrical power is less than 2 minutes.

Owing to the absence of power in the neighbourhood, a special plant for the generation of current had to be put down, consisting of two direct-coupled petrol engines driving two 50-kw. continuous-current machines, the current being delivered at the switchboards at 220 volts. A large storage-battery is provided, capable of supplying the motors with current for about 30 operations of the bridge before recharging is necessary.

Two sets of electric brakes are provided, and at the fore end of the span two heavy forged steel bolts, worked electrically from the control cabin, engage with castings anchored down to the pier, so locking the bridge when in the "down" position.

To prevent the too rapid descent of the leaf as it comes down on to the bearings, a pneumatic buffer is provided at the front of the span, whilst at the rear end bumping-blocks are provided on to which the counterweight comes down when the leaf attains its maximum elevation. Adjacent to these blocks hydro-pneumatic buffers are fixed, the rams of which, coming into contact with the counterweight, bring the bridge gradually to rest as it reaches its final position.

In order to meet the requirements of the navigation authorities, the lifting span was erected in a vertical position, 10 months being occupied in this work. Electrically operated gates are provided for the protection of roadway traffic, which are interlocked with the railway signals, which latter, it may be observed, are what are known as three-position signals, and are the first to be installed as a complete scheme in this country. Work was commenced in August, 1912, and following the Board of Trade tests, which were carried out in March and April, 1916, the bridge was opened to traffic on May 21.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, November 21, 1916.

† In our issue of June 23 last, on page 592, we published a general account of the Keadby Bridge, accompanied by illustrations on page 593 and Plate LI, a reference to which will be of interest in connection with Mr. Ball's paper.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on Friday, November 10, 1916, at the Imperial College of Science, Professor C. V. Boys, F.R.S., president in the chair, a paper entitled "*On Diffusion in Liquids*," was read by Mr. B. W. Clack, M.Sc.

The paper contains the results of the experiments described by the author in Proc. Phys. Soc. Lond., vol. xxi, page 374, 1908; vol. xxiv, page 40, 1911; and vol. xxvii, page 56, 1914, collected and recalculated in accordance with a theoretical correction recently communicated by Dr. Griffiths (Proc. Phys. Soc., vol. xxviii, page 255, 1916).

It is found that in the solutions employed the correction is not considerable, except in the case of the strongest solutions of KCl (2.7 normal), where it amounts to 6 per cent. The paper contains the corrected theory of the method, and the value of the coefficient of diffusion is tabulated at different limiting concentrations and at various temperatures; it concludes with a new method of calculating the coefficient at a definite concentration from the experimental results, which appears to be more accurate and free from questionable assumptions than previous calculations of a similar nature.

Discussion.—Professor G. W. O. Howe asked why the concentration was constant at the bottom of the diffusion tube in the author's apparatus.

Professor Boys thought this was an important point. He presumed that the upper bulb was sufficiently large that for the purposes of the experiment it could be regarded as an infinite reservoir. A steady state would then be maintained by the circulation through the side tubes, dilute solution rising up one into the reservoir, while more concentrated solution passed down the other.

Dr. R. S. Willows asked why the coefficient of diffusion was greater for strong than for weak solutions in the case of some salts, while the reverse was true for other salts.

Mr. Clack, in reply to Dr. Willows, said he did not know of any reason, but Dr. S. W. J. Smith had told him that that was what would be expected from conductivity data.

A paper "*On the Regularity in the Distribution of the Satellites of Spectrum Lines, with a Note on the Structure of the Green Line of Mercury, and Terms of Correction in Using a Concave Grating*," by Professor H. Nagaoka, was read, in the absence of the author, by Professor J. W. Nicholson.

The paper describes a further development of the work done by the author and Mr. Takamine on the distribution of the satellites of the mercury lines. The apparatus employed was a Fabry-Perot interferometer crossed with an echelon or Lummer-Gehrcke plate. An account of the theory governing the interpretation of crossed spectra is given.

It is shown that much of the discord between the results of various observers of these satellites is due to the unsatisfactory nature of the principal line as a datum from which to define their positions, and that if the distances be measured from one of the distinct satellites, good agreement is obtained.

If these separations be expressed as differences of wave-number, instead of wave-length, a remarkable symmetry in their distribution becomes apparent. For example, among the satellites of the green line, 5,461, can be found three groups of symmetrical triplets, of which the wave-number differences are in the simple ratios 1 : 3 : 12.

Similar results are obtained for other lines, the principal component of λ 4,359 being shown for the first time to consist of a triplet, of which the middle component is relatively weak.

A similarity in the distribution of the satellites exists for all the lines examined, and certain wave-number intervals are common to all.

It is observed that the intervals given by $l\frac{c}{3}$, $m\frac{c}{4}$, and $n\frac{c}{5}$, where $c = 0.71$, and l, m, and n are whole numbers, are found among the satellites of the eight lines quoted for $l = 1$ to 4, $m = 1$ to 7, and $n = 1$ to 7.

The possible origin of satellites is discussed in the light of the Zeeman and Stark effects, the magnetic or electric fields being electronic in origin, and many of the results are shown to be consistent with Voigt's theory of the vibrations of electrons in an isotropic, quasi-elastic, electric field. The suggested explanations can only be tentative as yet, pending further development of our knowledge of the theory of the Zeeman effect, and the extension of Sir J. J. Thomson's work on positive rays to a larger number of substances.

The second part of the paper consists of a mathematical investigation of terms of correction in the theory of large-sized concave gratings, which prevent the theoretical resolving power from being realised in practice.

Discussion.—Dr. H. S. Allen thought the paper contained many interesting and important points. That simple numerical relationships had been shown to hold for the separations of the satellites was likely to prove very helpful to those who were trying to solve the constitution of the atom. He was interested in the discussion of the part which might be played by the magnetic fields of atomic origin in these phenomena. He had himself held this idea for some time.

Dr. R. S. Willows did not quite understand the statement made at the beginning of the paper that there was, as yet, no observations of the effect of an electric field on the satellites, in view of the experiments of Stark, Lo Surdo and others.

Professor Nicholson, in reply, said he presumed the statement was intended to refer to the mercury satellites only.

The Late Mr. William Henry Bale.—We regret to have to record the death, which occurred on the 10th inst., in his 73rd year, of Mr. William Henry Bale, of Drakefell Lodge, St. Catherine's Park, London, S.E. Mr. Bale practised as a consulting engineer in Queen Victoria-street, E.C., for many years, and at the time of his death was head of the firm of Messrs. Bale and Hardy.

Pig-Iron in Germany.—The production of pig-iron within the German Customs Union during September, with 30 working days, amounted to 1,116,752 tons, against 1,145,239 tons in August, with 31 working days. The production per day, however, was slightly larger than during the previous month, the figures being respectively 37,225 tons and 36,943 tons. There was no material difference in the production of the different kinds; the decrease was comparatively small in the Rhineland-Westphalia district. The aggregate production for the month of September during the last four years was as follows:—1913, 1,590,849 tons; 1914, 580,087 tons; 1915, 1,034,124 tons; 1916, 1,116,752 tons. The greatest reduction in output for any one month during the war, compared with the corresponding month in the last year of peace, comes within the first month after the declaration of war, August, 1914, with a decrease of 64 per cent.

Society of Glass Technology.—A meeting was held on Thursday, the 9th inst., in the University of Sheffield, to discuss the formation of a Society of Glass Technology. The widespread interest in the scheme was demonstrated by the presence of representatives of cities as far apart as London, Edinburgh and Cardiff, whilst every glass manufacturing district was well represented. Mr. W. F. J. Wood, B.Sc., of Messrs. Wood Brothers, Limited, Barnsley, was elected to the chair, and the meeting opened with a cordial welcome from the vice-chancellor of the university, who stated that he had great pleasure on behalf of the university authorities in offering accommodation to the society. Sheffield had cause for legitimate pride in the knowledge that its university would be the headquarters of a body representing such an important industry. He emphasised the fact that this industry, among others, had suffered in the past owing to its detachment, wholly or partial, from its scientific aspects. The formation of the department of glass technology in the university was serving to remedy this state of affairs, and the inauguration of the society was a distinct step in the same direction. His sincere hope was that the society would be an active force not only in this country but throughout Europe, and no efforts must be remitted to make it truly representative of one of the oldest and most beautiful of industries. Dr. W. E. S. Turner outlined the steps that had led up to the formation of the society. Expressions of warm approval and promises of support had been received from all over the country. He pointed out that the society was in every way a national one. Meetings would be held from time to time in various centres, so that interest would be stimulated everywhere. It is to be hoped that the society will receive the support of all those interested in glass, either directly or indirectly. Information on any points will be gladly supplied by Dr. W. E. S. Turner, secretary, the University, Sheffield, who will welcome inquiries and suggestions.

THE PARALLEL OPERATION OF ELECTRIC POWER STATIONS.*

By JOHN S. PECK, Member.

IN Great Britain many municipalities have their own electric supply systems, and in several cases there are separate stations in the same city for traction and for power and lighting. In London there are very many independent stations, and throughout the country there are a considerable number of supply companies which furnish energy within certain definite areas. The possibility of linking up the stations in the different districts has often been considered, but it is only recently that the full advantages have been generally appreciated and that the problem has been attacked along broad lines.

It is not proposed in this paper to discuss the commercial questions involved in linking up, but to point out some of the engineering problems and to indicate what types of apparatus are available and the conditions under which they may be used.

Fortunately the great majority of stations in this country generate three-phase current at 50 periods, so that the problem of interconnecting is relatively simple. But there are a number of large systems which generate at 25 and 40 periods, several generate at 60 periods, two large stations generate at 33 periods, while a considerable number generate at other frequencies. These last are principally single-phase systems. The problem of linking up systems of different frequencies is much more complicated than that of linking up systems of the same frequency, and each particular case requires careful consideration in order to determine the best method to adopt.

Alternators in Parallel.—When two alternating-current generators having the same number of poles and the same rating are operated in parallel, they must, of course, run at exactly the same speed, and, if they are to divide the load equally, it is essential that the two engines (or turbines) driving them should have the same speed regulation, i.e., the same drop in speed from no load to full load. If one engine should have a regulation of 2 per cent. and the other of 4 per cent., then (assuming the regulation curve to be a straight line) with full load on one generator there would be only half load on the other. In other words, the load carried by the generator is determined by the amount of steam admitted to the engine, and not by the adjustment of the field strength of either machine, i.e., the load depends on the governor and not on the position of the field rheostat. Any two machines may be made to divide the load in any desired proportion by proper adjustment of the steam supply, while adjustments of the field rheostats simply cause wattless currents to flow between the generators. The effect of this current is to strengthen the field of the under-excited generator and to weaken that of the over-excited generator; thus the voltage across the two remains equal.

The operation of two or more stations in parallel is simply the operation of two or more groups of generators in parallel, and the conditions are similar to those involved in operating two single generators in parallel, except for the fact that the interconnecting line possesses inductance and resistance. For all ordinary cases the resistance and inductance may be neglected, but the matter is treated in a general way in Appendix 1.

Stations of the same Frequency Voltage and Phase.—When the stations to be linked up have the same frequency, voltage and phase, the only interconnecting link required is a cable with the necessary switches, &c., for connecting together the busbars of the two stations. It frequently happens, however, that the voltages of the two stations are not exactly equal, and it may be required to vary the voltage of either station independently of that of the other. For this reason it is desirable to have some form of voltage regulator in, at least, one of the stations, otherwise, when voltage adjustments are attempted, heavy wattless currents will flow between the stations and the voltages on the two systems will remain equal, except for the difference due to the drop of pressure in the cable.

The regulator may be either of the step-by-step or of the induction type.

Fig. 1 shows a diagram of connections which may be used when a step-by-step regulator is adopted. A, A, are series transformers for raising or lowering the voltage of the feeders; B, B, are shunt transformers, the secondaries of which are provided with tappings to give different voltages for applying to transformers A, A; C, C, are regulating dials; and D, D, are reversing switches. It will be noticed that only two regulators are required for the three phases.

In order to determine the size of cables, transformers, and regulator required to interconnect two systems it is necessary to know the maximum load which will have to be transmitted between them, and as this is the most important feature in parallel operation it will be considered in some detail.

It will be assumed first that the speed regulation of the two systems is identical, so that each will carry its proper proportion of the total load on both systems. This is a justifiable assumption, since the engine governor can usually be adjusted to give approximately this condition.

Fig. 1.

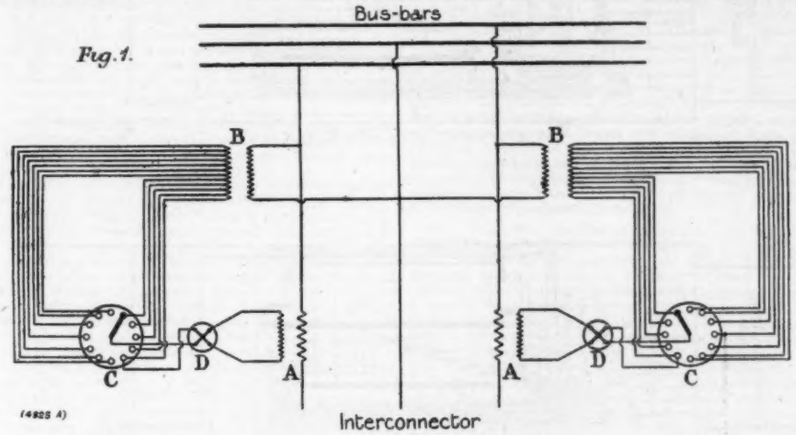


Fig. 2a.

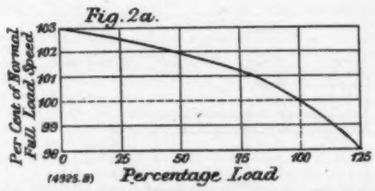
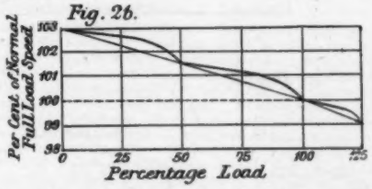


Fig. 2b.



With two stations A and B, the following cases will be considered:—

(1) A and B of equal capacity.
Unequal loads on the two stations.
(2) A of greater capacity than B.
Load on B greater than its proportion of the total capacity of the stations.
Load on B less than its proportion of the total capacity of the stations.

(1) *Load on Interconnector between Two Stations of Equal Capacity and the same Speed Regulation.*—Since A and B have equal capacities and must run in synchronism they will deliver at all times equal loads. Therefore, if the load on B's busbars is greater than that on A's busbars, half this difference will be supplied by each station, and the connecting feeder must carry half the difference in load.

Example.—Assume each station to have a capacity of 10,000 kw., and that there is a load on A's busbars of 15,000 kw. and on B's of 5,000 kw.; then the total load on the stations equals 20,000 kw. Each station will supply 10,000 kw. Therefore the load on the interconnector equals 10,000 − 5,000 = 5,000 kw., i.e., the load on the interconnector equals one-half of the difference in load on the busbars of the two stations.

(2) *Load on Interconnector between Two Stations of Unequal Capacity and same Speed Regulation.*—This case will be similar to the preceding one, except that instead of the total load being divided equally between the two stations it will be divided in proportion to their capacities. Knowing the load on the busbars and on the generators of each system, the load on the interconnector is known at once.

Example.—Assume A to have a capacity of 10,000 kw., B a capacity of 5,000 kw., i.e. (Capacity of A) : (Capacity of B) = 2 : 1. The load on each set of busbars = 6,000 kw. Then the total load = 12,000 kw. Of this load, A supplies 8,000 kw. and B 4,000 kw. The load on the interconnector = 6,000 − 4,000 = 2,000 kw., which flows from A to B.

If the load on A's busbars = 8,000 kw. and on B's busbars = 2,000 kw., the total load = 10,000 kw.; of this load, A delivers 6,666 kw., and B 3,333 kw., therefore the load on the interconnector = 8,000 − 6,666 = 1,333 kw., which flows from B to A.

It is evident from the above that if the load conditions are known, it is a very simple matter to calculate the load on the interconnecting line. If the loads are steady the engine governors may be adjusted by hand to give the minimum or any other desired load on the interconnector, but where violent fluctuations occur manual adjustments of the governor are impossible, and account must be taken of this fact when designing the interconnecting line.

When the engine governors of two systems are set for different speed regulations, they will divide the total load not in proportion to their generating capacities, but in direct proportion to their ratings and in inverse proportion to their speed regulation, assuming a straight-line speed drop. Thus, if station A has a rated capacity of 10,000 kw. and B 5,000 kw., while A drops 2 per cent. and B 4 per cent. in speed from no load to full load, the two stations will share the total load in the proportion of (10/5) × (4/2) = 4, i.e., A will deliver four times the load of B. If the regulation of A is 4 per cent. and that of B 2 per cent., then the proportion would be (10/5) × (2/4) = 1, i.e., the two stations would deliver equal loads. This would be a very dangerous condition, as B would be heavily overloaded before full load was reached on A. This simply confirms what is well known in operating machines in parallel, namely, that when the regulation cannot be made equal on two machines, the larger one should have the closer regulation.

Thus it is a simple matter to determine the distribution of load between two stations in parallel, provided the operating conditions and the speed regulation are known. The same methods may be used where there are several stations in parallel, and as soon as the loads on the different stations have been determined the load on the different interconnectors may be found.

In the above considerations it has been assumed that the drop in engine speed is proportional to the load, but, as a rule, the regulation curve is not exactly a straight line.

In a reciprocating engine, or turbine, with throttle-governing only, the speed curve is usually of the shape shown in Fig. 2*a*, while Fig. 2*b* shows approximately the curve for a steam turbine with "nozzle cut-out" governing. This curve approximates to a straight line more closely than does that of Fig. 2*a*, and it is evident that the greater the number of nozzle stages the more closely does the curve approach to a straight line. It will be noted that characteristics of curve 2*a*, and of each section of curve 2*b*, are a flat portion for the lower loads and a drooping position for the higher loads. The shape of curve shown in Fig. 2*a* is desirable for parallel operation, because, if the governors are not set exactly alike, the machine taking the greater load will tend to drop more rapidly in speed and thus shift its load to the machine which is operating on the flatter part of the speed curve. In the case of nozzle cut-out governing, it may happen that the machine taking the greater load reaches the straight part of one section of the curve while the other machine is on the drooping part of another section. In this case the more heavily loaded machine will tend to take still more load. This has one advantage, however, as a turbine works more economically on the drooping portion of any section of the curve than on the flat portion.

Although the speed curve may not be exactly a straight line, the distribution of load, as calculated by the methods given above, is sufficiently close for all practical purposes. In the actual parallel operation of alternators in a station the loads are seldom divided exactly in proportion to the ratings of the different machines, but shift from one set to another with variations in the external load, depending on the governor adjustments. This causes, however, no trouble in the station as long as the sets share their loads properly at the full output of the station, and hand adjustment of the governors is necessary from time to time. In the operation of stations in parallel exactly the same problems are involved, and there should be no more trouble than in operating different generators in the same station in parallel, provided that the interconnecting link is made of sufficient capacity to take care of any discrepancies in load adjustments due to governor peculiarities.

It is, of course, possible that in certain cases an automatic regulator could be used for adjusting the governor valves according to the load on the interconnector, but this is a refinement which is not likely to be required, as satisfactory operation can almost always be obtained without such a device.

Earthed Neutrals.—It is becoming standard practice in all large generating stations to earth the neutral point of the system. Where the busbars of two earthed systems are directly coupled together there may be heavy high-frequency currents flowing through earth between the stations, and these currents may cause trouble in telephone and telegraph circuits. There are several ways of overcoming this difficulty:—

(*a*) One station only may be earthed. In this case arrangements could be made so that when the interconnector is opened the unearthed system would be earthed.

(*b*) An insulated earth cable could be run from one system to the earth on the other system, *i.e.*, both systems would have a common earthed point.

(*c*) Transformers could be inserted in the interconnecting line.

(*d*) Reactances or resistances could be placed in the earth connection to limit the earth currents to a negligible value.

Stations of the same Frequency but of different Voltage or Phase.—Where the stations are of the same frequency

* Paper read before the Institution of Electrical Engineers, Thursday, November 23, 1916.

but of different phase or voltage, it is necessary to introduce transformers into the interconnector. The voltage and phase transformation is made, where such is required, in the same transformers.

Fig. 3 shows the diagram of connections used for the transformers of a 4,000-kw. interconnector between two stations in London, one generating 2,200 volts two-phase and the other 11,000 volts three-phase. For varying the voltage between the two stations step-by-step regulators are used. A drum-type oil-immersed regulator is used for changing from tap to tap.

Apart from the introduction of transformers, the operating conditions for stations having different voltages or phases are exactly the same as when the stations have the same voltage and phase, except where it is required to link up a single-phase system with a two- or three-phase system. If it is desired to distribute the load equally on all phases of the three-phase or two-phase system, rotating apparatus is required. This may take the form of a motor-generator or of what is known as a phase converter.

Several designs of phase converters have been proposed, but they all utilise the well-known fact that if one phase of a two or three-phase machine be supplied with current and the rotor be brought up to speed, then two-phase or three-phase current can be supplied from the four or three terminals of the motor. Various schemes are used for balancing the phases, but as this paper does not deal with the design of converting apparatus, the matter will not be discussed further.

This type of converting plant is used on the Norfolk and Western Railway in America for converting the single-phase trolley current into three-phase current for the motors on the locomotives. When running down grade the three-phase motors regenerate and supply single-phase current to the trolley through the converter. Similar plant is being installed in the sub-stations of a single-phase railway system for converting from three-phase to single-phase for supplying the trolley circuit.

Stations of different Frequencies.—When two stations of different frequencies are to be linked up it is necessary to use a frequency changer of the rotating type. This will usually take the form of a motor-generator, but in certain cases where continuous current is required it may be advantageous to use a rotary converter for changing from one frequency to continuous current, and another to change from continuous current to the other frequency. Under this condition it is of course possible to use both rotary converters for supplying continuous-current load from the two different systems. This condition will be considered later on.

The cost of a motor-generator is comparatively high, and while it is desirable to keep down its size to correspond to the load which it is desired to transmit from one station to the other, its capacity must also be chosen with reference to the load it may have to transmit under abnormal conditions, and the choice of the type of converting plant will be governed largely by this consideration.

The motor-generator for frequency transformation may be either of the following two types :—

Synchronous motor and synchronous generator—called "synchronous motor-generator."

Induction motor and synchronous generator—called "induction motor-generator."

Each set has certain advantages and disadvantages.

Synchronous Motor-Generator.— Since each machine of the set must run in synchronism with the system to which it is connected, the two systems must run at speeds which are definitely fixed with reference to each other. In other words, the two systems are locked together through the motor-generator, which acts as a perfectly rigid coupling, and it is the strength of this coupling with reference to the loads likely to be thrown on it which requires careful consideration in all cases.

Since the synchronous set locks the two systems in step, the transfer of energy from one system to the other will be governed by the same conditions as when the systems are of the same frequency and paralleled by a direct cable connection. Thus the loads likely to be thrown on the converting set may be calculated in the same way as described above for systems of the same frequency.

Advantages of Synchronous Set.—(1) It is reversible and can supply energy in either direction without change from the normal speed ratio.

(2) The motoring machine can be run at unity power factor, or even with a leading power factor, and thus assist in improving the power factor of the system. The generating machine may be run with an over-excited field, and so reduce the lagging current carried by other generators on the system.

Disadvantages.—(1) The set, acting as a rigid coupling, forces the two systems to run at a fixed speed ratio, and is therefore subject to heavy overloads under certain conditions.

(2) Each machine must be synchronised with its own system, an operation requiring some skill, especially with certain ratios between the numbers of poles.

(3) Where two motor-generators are operated in parallel, special arrangements are required in order to synchronise an unloaded set with one under load.

Induction Motor-Generator.—Where an induction motor and a synchronous generator are used, the induction motor does not run in synchronism with its supply system, but runs slightly below synchronous speed; the difference between its speed and synchronous speed (expressed as a percentage of the synchronous speed) is known as the slip, and this varies directly with the load transmitted. Furthermore, this slip may be regulated by adjusting the amount of resistance in series with the secondary number. The induction set may be likened to a slipping coupling between two prime movers where the amount of slip depends on the load transmitted, so that they are not required to operate at exactly the same speed.

The simplest way of understanding the working of the induction set is to take a concrete example. Assume two stations A and B, as in Fig. 4. Let the capacity of A be 10,000 kw., that of B 5,000 kw., and that of the motor-generator 1,000 kw. Assume the speed regulation of A and B to be each equal to 2 per cent., and the slip of the induction motor at full load to be 2 per cent. If there is no load on either station, and they are each running at normal speed, the set will run at synchronous speed and will transmit no load. If a load of 5,000 kw. is put on B's busbars, the speed of B will tend to drop 2 per cent., and if it is assumed that A keeps its no-load speed, 1,000 kw. will be transmitted through the motor-generator. But the load on A through the motor-generator will cause the speed of A to drop slightly, and since the load on B is now reduced by the amount supplied by A, the speed of B will not be reduced by quite 2 per cent., and the slip of the motor-generator being less than 2 per cent., it will transmit less than 1,000 kw. To be exact, it will be 770 kw. A method for determining the exact load on the frequency changer under different conditions will be found in Appendix 2. If the load be increased to 10,000 kw. the drop in speed of B will be doubled and the motor-generator will transmit approximately 1,600 kw., &c.

If with B giving a load of 5,000 kw., and the motor-generator transmitting 770 kw., the load on A be gradually increased, the speed of A will fall and the load transmitted from A to B will be reduced, until, when the speeds of the two sets have dropped by the same percentage, there will be no energy transmitted through the motor-generator.

As is well known, an induction motor will act as a generator if it is driven at a speed above the synchronous speed of the system to which it is connected. The load it will deliver as a generator when running at a certain speed above synchronism is the same as the load it will deliver as a motor when running with the same drop below synchronism. If, when motoring, full output requires 2 per cent. slip, then, when generating, full output will be obtained at 2 per cent. above synchronous speed.

Returning now to Fig. 4, if A and B are running without load, and the motor at synchronous speed, and a load of 10,000 kw. is put on A's busbars, the speed of A will tend to drop 2 per cent. with reference to B's

Fig. 3.

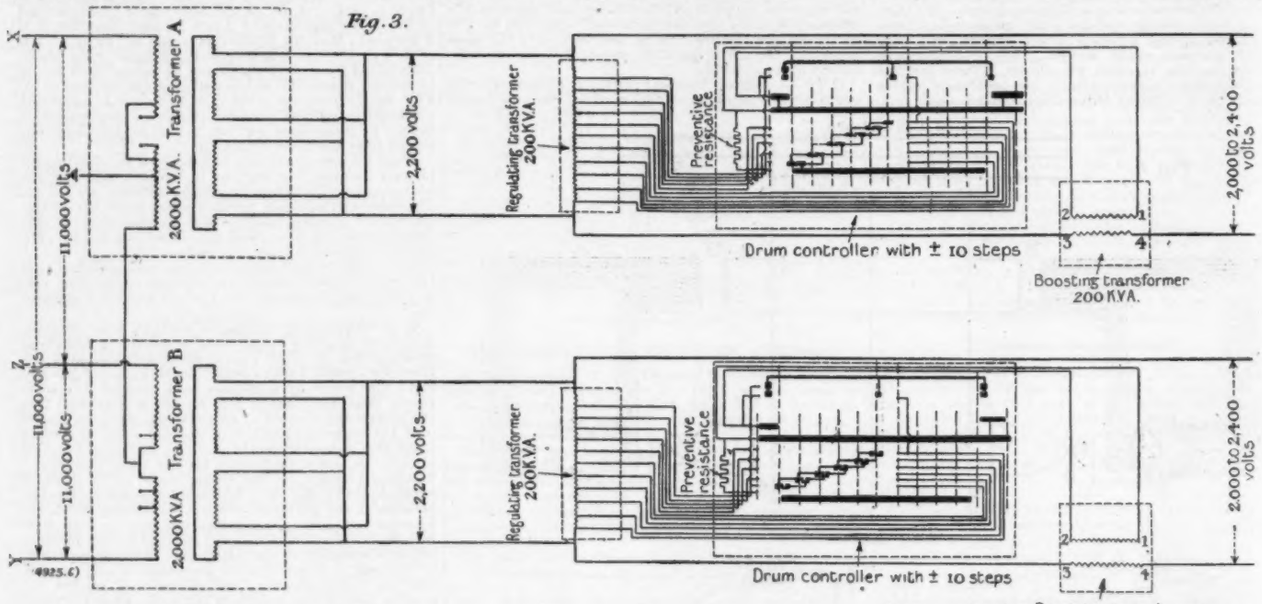


Fig. 4.

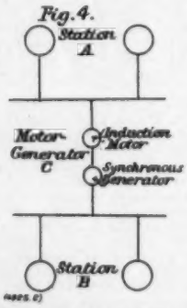
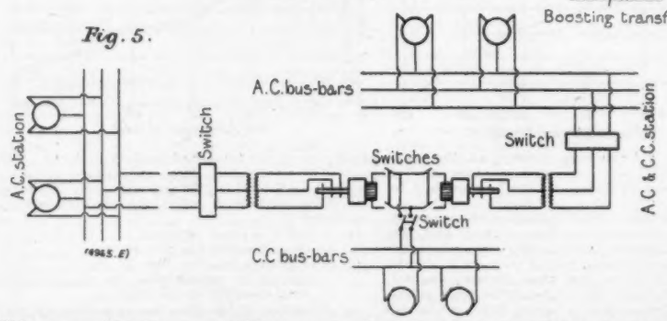


Fig. 5.



speed. This means that the induction machine is running approximately 2 per cent. above synchronism, since its speed is always fixed by B. It would therefore supply 1,000 kw. if B's speed remained constant. But a load of 1,000 kw. on B will cause its speed to drop 0.4 per cent., while the reduced load on A will means less than 2 per cent. drop, so that the set will not be running 2 per cent. above synchronism, but something less than 2 − 0.4 = 1.6 per cent. Thus it will deliver somewhat less than 800 kw. The exact distribution of load between the two stations may be calculated from the formulæ in Appendix 2, but it is easily approximated with a degree of accuracy quite sufficient for practical purposes.

From what has been said it will be obvious that the induction synchronous set is a much more flexible link for coupling up two power systems than is the synchronous set, and that it is possible to use a set of comparatively small capacity for linking up two large systems; for by making the slip fairly large it becomes almost impossible seriously to overload the set: also it requires a large variation in speeds to give a considerable transfer of energy from one system to the other. On the other hand, the induction machine always takes a wattless current, and does not permit any adjustment of power factor on the system to which it is connected.

Advantages of Induction Motor-Generator.—(1) It is a flexible link, and permits a small set to be used between two large systems.

(2) It is easier to start and put into operation.

(3) By using an adjustable secondary resistance, it is possible manually to control over a considerable range the amount of energy transmitted by the set, though this involves a certain loss in efficiency.

Disadvantages.—(1) A comparatively large difference in speed between the two systems is required in order that it may transfer its rated output from one to the other. This large difference in speed often limits the induction set to transmitting in one direction only.

(2) The induction machine requires a considerable lagging current, and no power-factor control is possible on this machine without introducing some form of phase advancer.

The great advantages which the synchronous set possesses, of permitting power-factor control and of transmitting energy in either direction without change in speed ratio between the two systems, make it desirable to use the synchronous set in preference to the induction set whenever possible. The great danger in its adoption is the possibility of overloading it and pulling it out of step. Of course it is possible to protect the machines from excessive overload by means of an overload circuit-breaker; but when the breaker opens the machine must be synchronized again, and for a time there is no interconnecting link between the two systems.

In general, a synchronous set should not be used unless its capacity is reasonably large with reference to the smaller of the two stations which it couples together—just what this relation should be depends upon a number of conditions. Where the stations are large and the changes in load comparatively small and not very sudden, it would probably be satisfactory to use a synchronous set having a rated capacity as low as 20 per cent. of the capacity of the smaller station. Under less favourable conditions it might not be advisable to use a capacity less than 40 to 50 per cent. of that of the smaller station. But where the synchronous set is as small as 20 per cent. of the capacity of the smaller station, overload protection must be provided and occasional shut-downs may be expected.

With the induction set there is practically no limit as to size; for, no matter how small the set, the slip of the induction machine may be made large enough to prevent serious overloading; but it must be remembered that the greater the slip the greater is the variation in speed ratio required to obtain a given transfer in energy between the two systems.

Interconnecting through Rotary Converters.—It was pointed out previously that under certain circumstances it might be desirable to interconnect two systems of different frequency by means of rotary converters. In general, this is only commercially feasible where continuous current is required in at least one of the stations. Fig. 5 shows two alternating-current stations of different frequency interconnected in this way. From the continuous-current side of the two rotary converters a connection is taken to the continuous-current busbars in one of the stations. With this arrangement it is possible to feed the continuous-current busbars from either or both alternating-current stations, or to supply alternating current from the continuous-current busbars to either or both stations; also it is possible to supply alternating current from either station to the other.

When rotary converters are used the transfer of energy from one station to the other does not depend upon the speed of the generators, but is controlled by manipulating the voltage of the rotary converters, and means must be provided for accomplishing this result. This may be done by synchronous boosters or by transformer tappings, but, in general, reactance control will permit sufficient voltage variation to give the desired results.

In many large continuous-current stations extensions are made at present with turbo plant. Where the units are of considerable size it is customary to use a high-speed turbine and to gear it to a moderate-speed continuous-current generator, or else to use a high-speed turbo-alternator and to convert to continuous current through a rotary converter. The latter arrangement offers a ready means of linking up with an alternating-current station, should it ever be desired to do so.

With an arrangement of the kind already discussed it is evident that there are a large number of possibilities with regard to linking up alternating and continuous-current stations.

(To be continued.)

CATALOGUES.

Switchboards.—The British Thomson-Houston Company, Limited, of Rugby, have prepared a limited number of folders containing three-colour reproductions of photographs showing some of the switchboards which they have manufactured recently. Besides high-tension alternating-current and large capacity direct-current boards, some extra-high-tension motor-operated gear is illustrated. The pictures have evidently been chosen with the idea of showing the diverse characters of the switchboards supplied by this firm, and they are beautifully reproduced on fine art paper.

Brake Solenoids for Electric Cranes.—A list dealing with totally enclosed brake solenoids has recently been issued by Mr. George Ellison, of Warstone-lane, Birmingham. That these solenoids have been the subject of much thought and investigation on the part of the manufacturers is plain from the large amount of information given in the list. Temperature rise is, of course, one of the most serious considerations in deciding on the purchase of a totally enclosed solenoid, and this is gone into very thoroughly with the assistance of rating curves. Some typical specifications are also given for guidance. Particulars of a large number of standard solenoids, of suitable discharge resistances, for both series and shunt working, &c., are given.

Electric Lighting Circuits.—The latest edition of Messrs. A. P. Lundberg's little booklet on electric wiring has been published in the French language, with the idea, no doubt, of making it available to the large number of Continental electricians who have come to England during the past two years. The idea of the booklet is, of course, to encourage the adoption of installations arranged in such a manner as to secure to the utmost the convenience possible with electric light. Instructions are given for wiring lamps controlled in all sorts of ways and combinations of ways, by means of three-pole, four-pole or any of the other special switches which Messrs. Lundberg manufacture. The subject is dealt with very thoroughly, and the price of 1 franc put on the booklet is very reasonable. The publishers' address is 477–489, Liverpool-road, London, N.

Iron Cements.—The Metalline Cement Company, of 112, Bath-street, Glasgow, have sent us a price list of their compounds for patching up defective castings, stopping leaks and similar purposes. There are four different grades of cement, chemically prepared in such a manner that they adhere permanently to the casting to which they are applied and, it is claimed, actually form a portion of it. The cements for filling up blow holes or other defects in castings are supplied as powders and only require mixing with water to be ready for use. A "flexible" cement, for patching leaking boilers, steam pipes, &c., is sold as a paste and hardens as soon as it is heated. These cements expand and contract to the same degree as cast-iron, and thus should not become loose through continued heating and cooling.

Grinding Wheels.—Messrs. Burton, Griffiths and Co., of Ludgate-square, Ludgate Hill, London, are putting on the market a new abrasive named "Boro-Carbone." This is an oxide of alumina (Al_2O_3) in crystalline formation, and is produced by fusing bauxite in the electric furnace by the arc process. Bauxite was considered infusible until the arc process was adopted in furnace work. The grade list of hardness of silicate and vitrified wheels includes 20 classes. The catalogue contains several pages of directions and advice in relation to grinding wheels and 32 pages of sections of wheels of various kinds and forms. The new abrasive is evidently being put on the market in a thoroughly organised manner, and users will find their requirements carefully provided for. Prices are quoted for all sizes and shapes.

Steam Turbines.—We have received from Messrs. Fraser and Chalmers, Limited, Erith, a copy of an excellently printed and copiously illustrated catalogue describing in detail the characteristic features of the steam turbine built by this firm. The standard pattern has one two-stage velocity compounded wheel followed by a number of simple impulse wheels. A notable example illustrated in the pamphlet is a turbine developing 6,300 kw. at 3,000 r.p.m. This machine was supplied to the South Metropolitan Electric Light and Power Company, Limited, and is stated to be running very satisfactorily. We note that the firm have now taken up the manufacture of the Terry steam turbine. This has a single wheel velocity compounded, and from its cheapness and simplicity is very suitable for such work as driving centrifugal pumps, small electric generators, forced-draught blowers and the like.

Portable Electric Tools.—From the Chicago Pneumatic Tool Company, of Fisher Building, Chicago, U.S.A., we have received a leaflet concerning portable electric tools for rail and tramway track laying. These have been specially designed for using the full voltage of American tramways, viz., 600 volts, and are manufactured to withstand the rough handling to which such tools are usually subjected. There is a very handy form of track drill, which is simply hooked on to the rail and held in place by the operator's weight. It is made in three sizes, for drilling up to ¾ in., 1 in. and 1¼ in. Two types of portable drill are also listed. Two electric grinders are illustrated, one of which has an offset spindle, driven by gearing, and is thus very convenient for working in awkward places. The wheel is 6 in. in diameter and runs at 3,000 r.p.m. The remaining tool is a rotary driver for screw spikes.

Gravitational Conveyors.—Messrs. W. and C. Pantin, of 147, Upper Thames-street, London, E.C., have sent us a pamphlet illustrating various applications of Mathews' patent gravity carrier, for which they are the sole agents. As its name suggests, the carrier is used for conveying goods from one place to another under the influence of gravity. It comprises a light steel framework carrying a series of rollers, or wheels, mounted on ball bearings, and thus is only suitable for transporting articles having a flat under-surface. These can be taken in any direction so long as a downward gradient of at least 2½ per cent. persists. For steep descents a spiral chute is employed, while if it is necessary to send the goods long distances they are first raised to the necessary height by means of an elevator. The illustrations show typical installations, one of which, at least, is 1,000 ft. long. In another case long pieces of timber are safely carried round a sharp right angle without it being necessary to have a guard to keep the timber on the rollers. The spacing of the rollers naturally depends on the length of the packages handled, as they must have a bearing on at least three rollers at all times. With 14-in. rollers spaced at 3 in. the carrier weighs 21 lb. per foot run. The wheel carrier, which is used for packages of 1 cwt. or less, weighs 5½ lb. per foot.

Boiler Fittings.—Some new pamphlets dealing with boiler fittings have recently been issued by the Crosby Steam Gauge and Valve Company, of 147, Queen Victoria-street, London, E.C. One of these illustrates and describes a boiler-feed regulator in which the linkwork usually employed to control the movement of the feed valve is dispensed with and its place taken by a column of water. The only moving parts are the valve, with its stem, and a rubber diaphragm which is not subjected to high temperatures. These regulators are suitable for pressures up to 240 lb. per square inch, and will maintain a constant water-level in the boiler within ½ in. They depend for their action on the generation of steam pressure in a confined space communicating with the feed-valve diaphragm. This steam pressure varies with the water-level and keeps the valve in such a position that the amount of water fed into the boiler always just balances that removed by evaporation. Another regulating device is for controlling the steam supply to the feed pumps and is actuated by the water pressure in the feed pipes. It is so arranged that the pump is speeded up or slowed down in proportion to the demand on the boilers for steam, and will also stop the pump in the event of the feed pipe bursting, or any similar accident. A third regulator is a very simple device for controlling the steam supply to furnace jets. It shuts off the supply when the working pressure is reached and opens the jet again if the pressure falls. The makers claim that this regulator will pay for itself in a few weeks.

Books.—The classified catalogue of works published by Messrs. Longmans, Green and Co., of 39, Paternoster-row, London, and also of New York, Chicago, Bombay, Calcutta and Madras, is arranged under the headings of standard and general works, theological works, Roman Catholic works, medical and surgical works, scientific works, educational works and Manchester University publications. The list of scientific works covers 52 pages, with some 12 to 15 entries on a page, and is divided into chemistry; physics; steam, oil and gas engines, motors, &c.; mechanics and mechanism; dynamics, statics, hydrostatics, hydraulics, &c.; sound, light, heat and thermodynamics; optics, photography, &c.; works by John Tyndall; architecture, building construction, &c.; electricity and magnetism; machine drawing and design; workshop appliances, &c.; naval architecture; astronomy, navigation, &c.; telegraphy and telephony; aeronautic engineering, strength of materials, &c.; geology, mineralogy, metallurgy, mining, &c.; works by Richard A. Proctor; manufactures, technology, &c.; natural history; health and hygiene; physiology, biology, zoology, &c.; bacteriology; agriculture and gardening; botany; advanced science manuals; practical elementary science series; text-books of science; elementary science manuals; monographs on physics; monographs on biochemistry; monographs on inorganic and physical chemistry; text-books of physical chemistry; civil engineering series; the architects' library; electrical engineering series; physical and electrical engineering laboratory manuals; technical handicraft series; and monographs on physiology. Messrs. Longmans also publish "Notes on Books," an analysis of new works, issued in March, June and November, and also separate catalogues, one of which deals with engineering, naval architecture, steam, manufactures and building. These are sent on application, post free.

THE SAM. EYDE FUND.—Mr. Sam. Eyde, the celebrated Norwegian inventor, has just completed his fiftieth year, on which occasion the Norwegian Hydro-Electric Nitrogen Company has set aside a sum of 100,000 kroner for the formation of a Sam. Eyde Fund, devoted to the advancement of chemical and physical research. The new fund is to be managed by the Board of the Nansen Fund. Dr. Sam. Eyde has had a remarkable career and, aided by Professor Birkeland, has succeeded in realising important schemes. The Norsk Hydro was founded on December 2, 1905, with a capital of 7,500,000 kroner, which has since been increased to 58,000,000 kroner, and has become the mother-company of a number of other vast concerns, which have turned to account some of the most powerful waterfalls in Norway. The factories at Notodden, based upon the exploitation of 40,000 h.p. from the Svälgfos fall, produce annually 16,000 tons of lime saltpetre and 2,500 tons of natrium nitrate, besides large quantities of by-products, but this first venture has been put entirely in the shade by the works Rjukan I and Rjukan II, with a capacity of 180,000 tons of nitrogen products annually. At both these latter industrial centres towns have sprung up, each with about 10,000 inhabitants.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

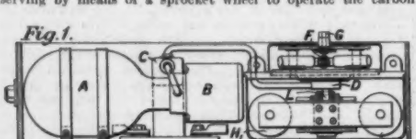
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

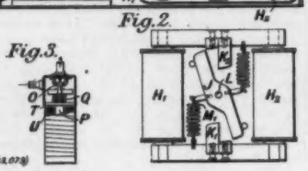
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

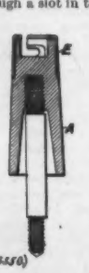
13,079/15. J. Brockie, London, and Johnson and Phillips, Limited, Charlton. Arc Lamps. (3 *Figs.*) September 13, 1915.—According to this invention, a small compressed air motor is employed to operate or move mechanically the carbon holders, and means are provided to regulate electrically the supply of air to the motor and to control the movements of the latter according to the requirements of the arc. A is a reservoir of compressed air; B a reducing valve connected to the main air valve C, from which pipes lead to a regulating valve D. The air engine comprises three cylinders, of which the pistons are connected to the same crank pin F, a pinion G on the crank serving by means of a sprocket wheel to operate the carbon





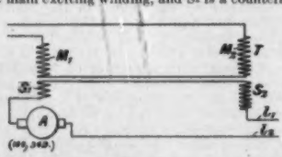
holders. The electrical regulating device comprises coils H1, H2 provided with a nearly closed iron magnetic circuit, of which K1, K2 are projecting poles. The coils are wound so as to produce consequent poles. The magnetic circuit is completed through an armature J, which is secured to a spindle L. The magnetic attraction between the ends of the armature J and the poles K1, K2 is opposed by springs. The spindle L is connected to the spindle of the regulating valve D. The main valve C comprises a taper valve O, which is closed by a spring Q and opened by a plunger P moving within coils T and U, energised respectively from currents in shunt and series with the carbon electrodes; both windings co-operate in their action on the plunger P. (*Accepted September* 20, 1916.)

16,550/15. J. B. Alexander, London. Telegraph Line Insulator. (2 *Figs.*) November 23, 1915.—This invention relates to insulators and the type in which the wire engages with the insulator when the latter is nearly screwed down upon its base by passing down through a slot in the head of the insulator



in which it can be gripped by a slight further turning of the cap on its base. According to this invention, the insulating material of the top of the insulator A is partly surrounded by a sheath of sheet metal or coiled wire, or wire-gauze reinforcement E, preferably embedded in the insulating material. (*Accepted September* 20, 1916.)

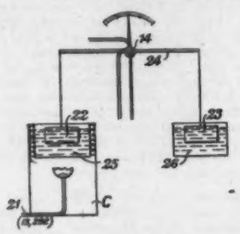
100,394. Allmanna Svenska Elektriska Aktiebolaget, Westeras, Sweden. Electric Generators. (4 *Figs.*) May 5, 1915.—The invention relates to continuous-current generators of the shunt or separately excited type. A denotes the armature of a separately excited generator feeding the load circuit l1, l2, M1, is the main exciting winding, and S1 is a counteracting series



winding for limiting the short-circuit current. T is a transformer, one winding S2 of which is connected in series with the load circuit, while the other winding M2 is connected in series with the exciting winding M1. The windings S2 and M2 have such a mutual direction of winding, that on a variation of the load current an E.M.F. is induced in the winding M2 directed oppositely to that induced in the winding M1 from the winding S1. The windings M1, S2 and M2 may be so adjusted that these induced E.M.Fs. are caused to neutralise each other, thus effecting a rapid decrease of magnetic flux in the generator, for instance, in case of short-circuits. (*Accepted September* 20, 1916.)

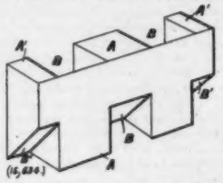
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

13,292/15. J. F. Simmance, London. Gas Manufacture. (3 *Figs.*) September 17, 1915.—The present invention relates to apparatus for the automatic control of various processes in the manufacture of gas, and is applicable to plants for the production of gas from retorts or producers for lighting, heating or power purposes. In the arrangement illustrated, a simple non-recording calorimeter C is employed. A supply of gas is drawn from the gas-making plant by the pipe 21 and is burned at a definite rate inside the calorimeter. Two floats 22 and 23 are suspended at opposite ends of a beam 24, and dip into liquids contained in two tanks 25 and 26. The liquid in the tank 25 is inside the calorimeter and is heated by the gas jet. The beam and floats are



initially balanced, so that when the gas being burned is of the desired calorific value the float 22 is submersed below the level of liquid in the tank 25. If the calorific value of the gas being burned is higher or lower than the desired standard, the float 22 tends to sink to the bottom of the tank or to rise to the surface of the liquid, owing to the variation of temperature of the liquid and the consequent variation of the mass of liquid displaced by the float. A small variation of temperature may be made to give a comparatively large variation in the angular position of the beam. Such variations of the angular position of the beam may be caused to operate the three-way cock 14 which controls the water loading of the regulating apparatus of the gas-producing plant. (*Accepted September* 20, 1916.)

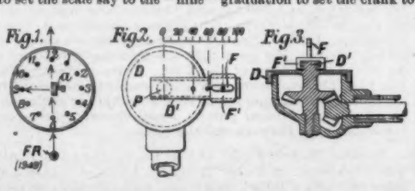
16,634/15. E. J. Davison, London, and C. P. Tooley, Leeds. Coke Oven Chambers. (10 *Figs.*) November 25, 1915.—This invention relates to chequer bricks of the type having equal and uniform alternate square pedestals A and fine-edged recesses B arranged in staggered formation on their upper and



lower surfaces and having the end pedestals A1 and recesses B1 of a length equal to one-half only of the unit width of brick. In accordance with this invention, the said fine-edged recesses B are constructed of a single-bevelled form, obliquely arranged at any desired angle, and with the bevel either flat, convex or concave. (*Accepted September* 20, 1916.)

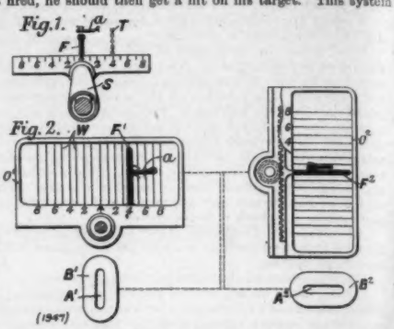
GUNS AND EXPLOSIVES

1,949/15. W. A. Burns, Drummondhill. Ordnance. (4 *Figs.*) August 7, 1914.—This invention relates to speed sights. a represents an aeroplane as target, which is assumed to lie at the centre of a clock-face or dial and to fly towards one of the hours. The dial is so positioned that the line of sight from the firer F R to the target passes through the six o'clock division. Hence a target flying from right to left crossing the firer's line of sight at right angles may be called "nine o'clock," or more shortly a "nine" target. A "six" target is one flying directly towards the firer, and so on. D1 (Figs. 2 and 3) is a crank carrying a sighting index F mounted on a base F1, so carried by the crank that it can be set to various distances from the centre of rotation of the crank to vary the speed allowance. The crank arm D1 may be carried on a turntable D provided with a circular scale divided into 12 parts, numbered from 1 to 12 respectively, corresponding with the hours of direction as in Fig. 1, the arrangement being such that it is only necessary to set the scale say to the "nine" graduation to set the crank to



its rotary position for a "nine o'clock" target. The scale shown in Fig. 2, graduated from 0 to 100, is assumed to show distances measured from the zero point P, to which the foresight has to be moved on the crank to be correctly "set" for targets having speeds up to 100 m.p.h. The cross bar of the T-shaped foresight F may be made wide enough to span the interval between 65 and 95, and thus indicate to the firer to what extent he must "spread" his fire to make sure of hitting one or more of the aeroplanes the speeds of which lie somewhere within the 65 m.p.h. and 95 m.p.h. limits, their line of flight being at right angles to the line of fire. As the target's direction becomes more and more parallel to the line of fire, the required amount of lateral spread of fire, so to speak, becomes less and less, until with a "six" or "twelve" target no lateral spread is required. Now as the crank is rotated concurrently with such changes of target direction the width of the cross bar of the foresight appears to be reduced simultaneously, until at "six" or "twelve" it is as shown in Fig. 3. (*Accepted August* 16, 1916.)

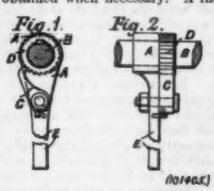
1,947/15. W. A. Burns, Drummondhill. Ordnance. (6 *Figs.*) August 7, 1914.—This invention relates to speed sights. S is a sight bar having a horizontal scale graduated to the right and left of a zero arrow, and F is the actual aiming index or foresight, which is capable of being traversed horizontally from one end of the scale to the other. The figure shows the index F at zero aimed at a target aeroplane a flying from right to left. It is assumed that a shot has been fired and that T is a part of the path of the projectile, or its smoke trail as seen when the aim is made to follow the moving target. The firer having noted that it cuts division 4 on the right, at once traverses his foresight till the stem is opposite this division and then fires again at his target. Provided the conditions as to target speed and direction are the same (or nearly so) as when the first round was fired, he should then get a hit on his target. This system



may require an aperture back sight for its most effective use. In the case of ordnance layed by two layers, one laying for elevation and the other for direction, the two foresights may consist of open frames O1 and O2, as shown in Fig. 2, and the scales may be supplemented by vertical (or horizontal) wires or "graticules" W, the foresights or movable aiming indices F1 and F2 respectively consisting of thicker wire than the rest. In such a case, or in any case where layers lay for line and for elevation separately, the aperture back sights B1 and B2 may have long vertical and horizontal slits A1, A2 respectively, instead of the usual circular holes, the layer for line using the vertical slit A1 with the vertical wires W, and aiming index F1, while the layer for elevation uses the horizontal slit B1 with the horizontal wires W and aiming index F2. (*Accepted August* 16, 1916.)

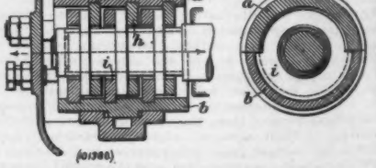
MACHINE AND OTHER TOOLS, SHAFTING, &c.

101,405. C. Downs, and W. B. Littlejohn, Kingston-upon-Hull. Boring Machines. (3 *Figs.*) September 10, 1915.—The present invention has for its object to provide boring and like machines with means for enabling the lead-screw, in addition to being operated or rotated automatically by mechanical means, as heretofore, to be operated or rotated by hand when desired, whereby a reduced speed of feed of the cutter or tool can be obtained when necessary. A indicates a sleeve



forming part of a ratchet device and which is mounted on that portion of the lead-screw B which is not provided with a screw thread, the pawl C of such rachet device being adapted to engage teeth formed around the lead-screw spindle, or around a collar D fitted thereon, E being the operating handle of the device, which is formed integral with or secured to the sleeve A, to which handle the pawl C is loosely pinned. (*Accepted September* 20, 1916.)

101,380. Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland. Thrust Bearings. (15 *Figs.*) December 16, 1915.—The invention relates to adjustable thrust bearing with a divided bearing brass, the halves *a*, *b*, of which are adapted to be adjusted independently in the axial direction and carry thrust rings, *h*, *i*. In accordance with this invention, one group



of thrust rings *h* is fixed only in the one half *a*, and the other group of thrust rings *i* is fixed only in the other half *b* of the bearing brass, the arrangement being such that the thrust rings encircle the shaft so that the thrust surfaces of each of the two groups of thrust rings receive the axial thrust of the shaft in an at least approximately central manner. (*Accepted September* 20, 1916.)

DANISH SHIPPING.—According to official statistics just published as to the doings of Danish shipping during 1915, it is of interest to note that whilst the steamer tonnage had been about stationary during the last three years, the motor-vessel tonnage had been doubled, from 30,000 tons at the end of 1913 to 59,000 tons at the end of 1915. The gross earnings during 1915, exclusive of time charters, of Danish shipping amounted to an aggregate of 218,700,000 kroner, against 95,100,000 kroner for 1914 and 102,000,000 kroner for 1913; the time-charter earnings being respectively 8,700,000 kroner, 3,600,000 kroner and 7,500,000 kroner. (18 kroner = 1*l.*)